

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
8 November 2001 (08.11.2001)

PCT

(10) International Publication Number
WO 01/83520 A2

- (51) International Patent Classification⁷: **C07K 9/00**
- (21) International Application Number: **PCT/US01/13980**
- (22) International Filing Date: **1 May 2001 (01.05.2001)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:
60/201,178 2 May 2000 (02.05.2000) US
60/213,415 22 June 2000 (22.06.2000) US
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- (54) Title: **POLYACID GLYCOPEPTIDE DERIVATIVES**
- (57) Abstract: Disclosed are derivatives of glycopeptides that are substituted at the C-terminus with a substituent that comprises two or more (e.g. 2, 3, 4, or 5) carboxy (CO₂H) groups; and pharmaceutical compositions containing such glycopeptide derivatives. The disclosed glycopeptide derivatives are useful as antibacterial agents.
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- (81) Designated States (national): **AE, AG, AI, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.**
- (84) Designated States (regional): **ARIPO** patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), **Eurasian** patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), **European** patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), **OAPI** patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

--- without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/83520 A2

POLYACID GLYCOPEPTIDE DERIVATIVES

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PRIORITY OF INVENTION

This application claims priority to United States Provisional Application Number 60/201,178, filed 02 May 2000; and to United States Provisional Application Number 60/213,415, filed 22 June 2000, which applications are incorporated herein by reference in their entirety.

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BACKGROUND OF THE INVENTION

Field of the Invention

This invention is directed to novel polyacid derivatives of glycopeptide antibiotics and related compounds. This invention is also directed to pharmaceutical compositions containing such glycopeptide derivatives, methods of using such glycopeptide derivatives as antibacterial agents, and processes and intermediates useful for preparing such glycopeptide derivatives.

Background

Glycopeptides (e.g., dalbaheptides) are a well-known class of antibiotics produced by various microorganisms (see *Glycopeptide Antibiotics*, edited by R. Nagarajan, Marcel Dekker, Inc. New York (1994)). These complex multi-ring peptide compounds are very effective antibacterial agents against a majority of Gram-positive bacteria. Although potent antibacterial agents, the glycopeptides antibiotics are not used in the treatment of bacterial diseases as often as other classes of antibiotics, such as the semi-synthetic penicillins, cephalosporins and lincomycins, due to concerns regarding toxicity.

In recent years, however, bacterial resistance to many of the commonly-used antibiotics has developed (see J. E. Geraci et al., *Mayo Clin. Proc.* 1983, 58, 88-91; and M. Foldes, *J. Antimicrob. Chemother.* 1983, 11, 21-26). Since glycopeptide antibiotics are often effective against these resistant strains of bacteria, glycopeptides such as vancomycin have become the drugs of last resort

for treating infections caused by these organisms. Recently, however, resistance to vancomycin has appeared in various microorganisms, such as vancomycin-resistant enterococci (VRE), leading to increasing concerns about the ability to effectively treat bacterial infections in the future (see Hospital Infection Control Practices Advisory Committee, *Infection Control Hospital Epidemiology*, 1995, 17, 364-369; A. P. Johnson et al., *Clinical Microbiology Rev.*, 1990, 3, 280-291; G. M. Eliopoulos, *European J. Clinical Microbiol., Infection Disease*, 1993, 12, 409-412; and P. Courvalin, *Antimicrob. Agents Chemother*, 1990, 34, 2291-2296).

A number of derivatives of vancomycin and other glycopeptides are known in the art. For example, see U.S. Patent Nos. 4,639,433; 4,643,987; 4,497,802; 4,698,327; 5,591,714; 5,840,684; and 5,843,889. Other derivatives are disclosed in EP 0 802 199; EP 0 801 075; EP 0 667 353; WO 97/28812; WO 97/38702; WO 98/52589; WO 98/52592; and in *J. Amer. Chem. Soc.*, 1996, 118, 13107-13108; *J. Amer. Chem. Soc.*, 1997, 119, 12041-12047; and *J. Amer. Chem. Soc.*, 1994, 116, 4573-4590.

Despite the above referenced disclosures, a need currently exists for novel glycopeptide derivatives having effective antibacterial activity and an improved mammalian safety profile. In particular, a need exists for glycopeptide derivatives which are effective against a wide spectrum of pathogenic microorganisms, including vancomycin-resistant microorganisms.

SUMMARY OF THE INVENTION

The present invention provides novel polyacid glycopeptide derivatives having highly effective antibacterial activity.

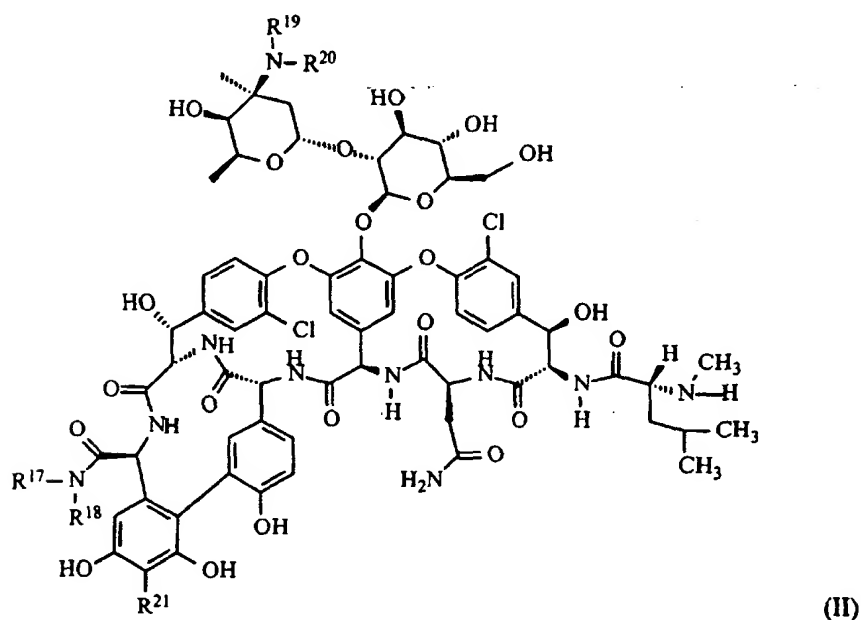
Accordingly, the invention provides a compound of the invention, which is a glycopeptide substituted at the C-terminus with a substituent that comprises two or more (e.g. 2, 3, 4, or 5) carboxy (CO₂H) groups; or a pharmaceutically acceptable salt, or stereoisomer, or prodrug thereof.

Preferably, the substituent is attached to a carbonyl group of the C-terminus to form an amide bond, an ester bond, or a thioester bond. More preferably, the substituent is attached to a carbonyl group of the C-terminus to

form an amide bond. More preferably, the substituent comprises two carboxy (CO₂H) groups. Preferred substituents at the C-terminus include a nitrogen-linked aspartic acid or a nitrogen linked glutamic acid.

Certain glycopeptide derivatives were disclosed by A. Malabarba, et al.,
 5 *J. Med. Chem.*, 1989, 32, 2450-2460. Accordingly, the compounds of the invention may preferably exclude the glycopeptides 1) teicoplanin A2 substituted at the C-terminus with a nitrogen-linked glutamic acid, and 2) teicoplanin aglycon (TD) substituted at the C-terminus with a nitrogen-linked glutamic acid.

10 Other glycopeptide derivatives are also described in U.S. Patent Application Serial Number 09/470,209, filed 22 December 1999. Accordingly, the compounds of the invention may also preferably exclude glycopeptides of formula II:



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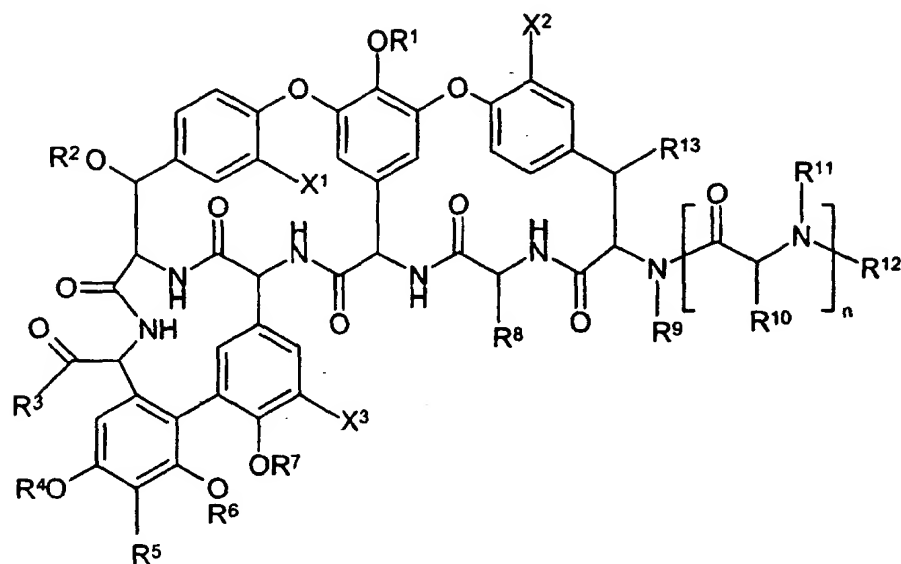
- a) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is hydrogen;
- b) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(9-hydroxydecylamino)ethyl; and R²¹ is hydrogen;

- c) wherein R¹⁷ is 1,4-dicarboxybutyl; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is hydrogen; or
- d) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is -CH₂-N-(D-glucamine).

The invention also preferably exclude glycopeptides of formula II:

- e) wherein R¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-[4-(4-chlorobenzyloxy)benzylamino]ethyl; and R²¹ is hydrogen;
- f) wherein NR¹⁷ is 5-(2-carboxypyrrolidin-1-ylcarbonyl)-5-(2-carboxy-3-phenylpropylamino)pentylamino; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is hydrogen;
- g) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is -CH₂-N-(N-CH₃-D-glucamine);
- h) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is N-[2-(2-hydroxyethoxy)ethyl]-aminomethyl; or
- i) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(4-isobutylbenzyl)ethyl; and R²¹ is N-[2-(2-hydroxyethoxy)ethyl]aminomethyl.

A preferred compound of the invention is a glycopeptide of formula I:



(I)

wherein:

R¹ is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl, heterocyclic and -R^a-Y-R^b-(Z)_x; or R¹ is a saccharide group optionally substituted with -R^a-Y-R^b-(Z)_x, R^f, -C(O)R^f, or -C(O)-R^a-Y-R^b-(Z)_x;

R² is hydrogen or a saccharide group optionally substituted with -R^a-Y-R^b-(Z)_x, R^f, -C(O)R^f, or -C(O)-R^a-Y-R^b-(Z)_x;

R³ is a nitrogen-linked, oxygen-linked, or sulfur-linked substituent comprising two or more carboxy groups;

R⁴ is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, -R^a-Y-R^b-(Z)_x, -C(O)R^d and a saccharide group optionally substituted with -R^a-Y-R^b-(Z)_x, R^f, -C(O)R^f, or -C(O)-R^a-Y-R^b-(Z)_x;

R⁵ is selected from the group consisting of hydrogen, halo, -CH(R^c)-NR^cR^c, -CH(R^c)-NR^cR^c, -CH(R^c)-R^a, -CH(R^c)-NR^c-Ra-C(=O)-R^a, and -CH(R^c)-NR^c-R^a-Y-R^b-(Z)_x;

R^6 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, $-R^a-Y-R^b-(Z)_x$, $-C(O)R^d$ and a saccharide group optionally substituted with $-NR^c-R^a-Y-R^b-(Z)_x$, or R^5 and R^6 can be joined, together with the atoms to which they are attached, form a heterocyclic ring optionally substituted with $-NR^c-R^a-Y-R^b-(Z)_x$;

R^7 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, $-R^a-Y-R^b-(Z)_x$, and $-C(O)R^d$;

R^8 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic;

R^9 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic;

R^{10} is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic; or R^8 and R^{10} are joined to form $-Ar^1-O-Ar^2-$, where Ar^1 and Ar^2 are independently arylene or heteroarylene;

R^{11} is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic, or R^{10} and R^{11} are joined, together with the carbon and nitrogen atoms to which they are attached, to form a heterocyclic ring;

R^{12} is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl, heterocyclic, $-C(O)R^d$, $-C(NH)R^d$, $-C(O)NR^cR^e$, $-C(O)OR^d$, $-C(NH)NR^cR^e$ and $-R^a-Y-R^b-(Z)_x$, or R^{11} and R^{12} are joined, together with the nitrogen atom to which they are attached, to form a heterocyclic ring;

R^{13} is selected from the group consisting of hydrogen or $-OR^{14}$;

R^{14} is selected from hydrogen, $-C(O)R^d$ and a saccharide group;

each R^a is independently selected from the group consisting of alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted alkynylene;

each R^b is independently selected from the group consisting of a covalent bond, alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted alkynylene, provided R^b is not a covalent bond when Z is hydrogen;

each R^c is independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl, heterocyclic and $-C(O)R^d$;

each R^d is independently selected from the group consisting of alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic;

R^e is a saccharide group;

each R^f is independently alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl, or heterocyclic;

R^x is an N-linked amino saccharide or an N-linked heterocyclic;

X^1 , X^2 and X^3 are independently selected from hydrogen or chloro;

each Y is independently selected from the group consisting of oxygen, sulfur, $-S-S-$, $-NR^e-$, $-S(O)-$, $-SO_2-$, $-NR^eC(O)-$, $-OSO_2-$, $-OC(O)-$, $-NR^eSO_2-$, $-C(O)NR^e-$, $-C(O)O-$, $-SO_2NR^e-$, $-SO_2O-$, $-P(O)(OR^e)O-$, $-P(O)(OR^e)NR^e-$, $-OP(O)(OR^e)O-$, $-OP(O)(OR^e)NR^e-$, $-OC(O)O-$, $-NR^eC(O)O-$, $-NR^eC(O)NR^e-$, $-OC(O)NR^e-$, $-C(=O)-$ and $-NR^eSO_2NR^e-$;

each Z is independently selected from hydrogen, aryl, cycloalkyl, cycloalkenyl, heteroaryl and heterocyclic;

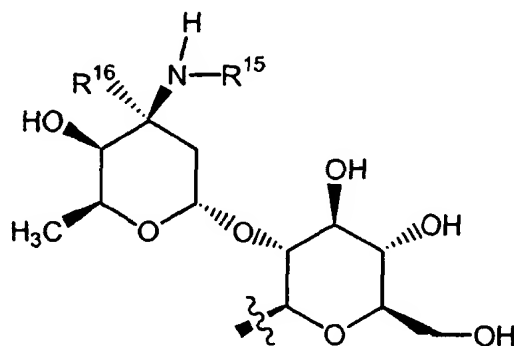
n is 0, 1 or 2; and

x is 1 or 2;

or a pharmaceutically acceptable salt, or stereoisomer, or prodrug thereof.

- Preferably, R^1 is a saccharide group optionally substituted with
 $-R^a-Y-R^b-(Z)_x$, R^f , $-C(O)R^f$, or $-C(O)-R^a-Y-R^b-(Z)$. More preferably R^1 is
 an amino saccharide group substituted on the saccharide nitrogen with
- 5 $-CH_2CH_2-NH-(CH_2)_9CH_3$; $-CH_2CH_2CH_2-NH-(CH_2)_8CH_3$;
 $-CH_2CH_2CH_2CH_2-NH-(CH_2)_7CH_3$; $-CH_2CH_2-NHSO_2-(CH_2)_9CH_3$;
 $-CH_2CH_2-NHSO_2-(CH_2)_{11}CH_3$; $-CH_2CH_2-S-(CH_2)_8CH_3$;
 $-CH_2CH_2-S-(CH_2)_9CH_3$; $-CH_2CH_2-S-(CH_2)_{10}CH_3$;
 $-CH_2CH_2CH_2-S-(CH_2)_8CH_3$; $-CH_2CH_2CH_2-S-(CH_2)_9CH_3$;
 $-CH_2CH_2CH_2-S-(CH_2)_3-CH=CH-(CH_2)_4CH_3$ (*trans*); $-CH_2CH_2CH_2CH_2-$
 10 $S-(CH_2)_7CH_3$; $-CH_2CH_2-S(O)-(CH_2)_9CH_3$; $-CH_2CH_2-S-(CH_2)_8Ph$;
 $-CH_2CH_2-S-(CH_2)_8Ph$; $-CH_2CH_2CH_2-S-(CH_2)_8Ph$; $-CH_2CH_2-NH-CH_2-4-(4-$
 $Cl-Ph)-Ph$; $-CH_2CH_2-NH-CH_2-4-[4-(CH_3)_2CHCH_2-]Ph$; $-CH_2CH_2-NH-CH_2-$
 $4-(4-CF_3-Ph)-Ph$; $-CH_2CH_2-S-CH_2-4-(4-Cl-Ph)-Ph$; $-CH_2CH_2-S(O)-CH_2-4-$
 $(4-Cl-Ph)-Ph$; $-CH_2CH_2CH_2-S-CH_2-4-(4-Cl-Ph)-Ph$;
 15 $-CH_2CH_2CH_2-S(O)-CH_2-4-(4-Cl-Ph)-Ph$; $-CH_2CH_2CH_2-S-CH_2-4-[3,4-di-Cl-$
 $PhCH_2O)-Ph$; $-CH_2CH_2-NHSO_2-CH_2-4-[4-(4-Ph)-Ph]-Ph$;
 $-CH_2CH_2CH_2-NHSO_2-CH_2-4-(4-Cl-Ph)-Ph$; $-CH_2CH_2CH_2-NHSO_2-CH_2-4-$
 $(Ph-C\equiv C)-Ph$; $-CH_2CH_2CH_2-NHSO_2-4-(4-Cl-Ph)-Ph$; or
 $-CH_2CH_2CH_2-NHSO_2-4-(naphth-2-yl)-Ph$. Preferably R^1 is also an amino
 20 saccharide group substituted on the saccharide nitrogen with a 4-(4-
 chlorophenyl)benzyl group or with a 4-(4-chlorobenzyloxy)benzyl group.

R^1 can also be a saccharide group of the formula:



wherein R^{15} is $-R^a-Y-R^b-(Z)_x$, R^f , $-C(O)R^f$, or $-C(O)-R^a-Y-R^b-(Z)_x$; and R^{16}
 is hydrogen or methyl.

- 25 Preferably, R^2 is hydrogen.

$\text{CH}_2\text{-NH-CH}_2\text{CH}_2\text{-S-(CH}_2\text{)}_{10}\text{Ph}$; $\text{-CH}_2\text{-NH-CH}_2\text{CH}_2\text{-S-CH}_2\text{-(4-(4-CF}_3\text{-Ph)Ph)}$; $\text{-CH}_2\text{-NH-CH}_2\text{CH}_2\text{-NH-(CH}_2\text{)}_{11}\text{CH}_3$; or $\text{-CH}_2\text{-NH-(CH}_2\text{)}_5\text{-COOH}$;

Preferably, R^8 is $\text{-CH}_2\text{C(O)NH}_2$, $\text{-CH}_2\text{COOH}$, benzyl, 4-hydroxyphenyl or 3-chloro-4-hydroxyphenyl.

5 Preferably, R^9 is hydrogen or alkyl.

Preferably, R^{10} is alkyl or substituted alkyl. More preferably, R^{10} is the side-chain of a naturally occurring amino acid, such as isobutyl.

Preferably, R^{11} is hydrogen or alkyl.

10 Preferably, R^{12} is hydrogen, alkyl, substituted alkyl or -C(O)R^d . R^{12} can also preferably be hydrogen; $\text{-CH}_2\text{COOH}$; $\text{-CH}_2\text{-[CH(OH)]}_5\text{CH}_2\text{OH}$; $\text{-CH}_2\text{CH(OH)CH}_2\text{OH}$; $\text{-CH}_2\text{CH}_2\text{NH}_2$; $\text{-CH}_2\text{C(O)OCH}_2\text{CH}_3$; $\text{-CH}_2\text{-(2-pyridyl)}$; $\text{-CH}_2\text{-[CH(OH)]}_4\text{COOH}$; $\text{-CH}_2\text{-(3-carboxyphenyl)}$; $(R)\text{-C(O)CH(NH}_2\text{)(CH}_2\text{)}_4\text{NH}_2$; -C(O)Ph ; $\text{-C(O)CH}_2\text{NHC(O)CH}_3$; $E\text{-CH}_2\text{CH}_2\text{-S-(CH}_2\text{)}_3\text{CH=CH(CH}_2\text{)}_4\text{CH}_3$; or -C(O)CH_3 .

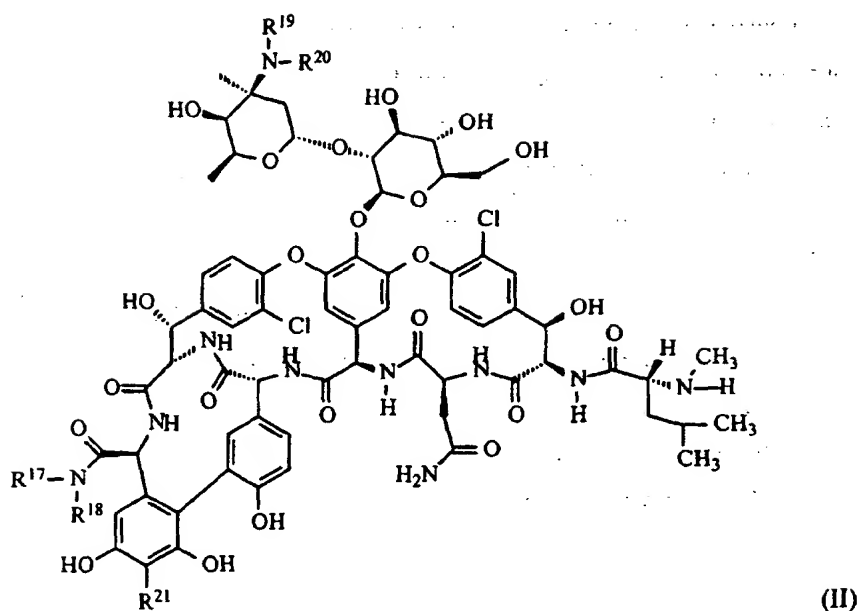
15 Preferably, X^1 and X^2 are each chloro.

Preferably, X^3 is hydrogen.

20 Preferably each Y is independently selected from the group consisting of oxygen, sulfur, -S-S- , $\text{-NR}^c\text{-}$, -S(O)- , $\text{-SO}_2\text{-}$, $\text{-NR}^c\text{C(O)-}$, $\text{-OSO}_2\text{-}$, -OC(O)- , $\text{-NR}^c\text{SO}_2\text{-}$, $\text{-C(O)NR}^c\text{-}$, -C(O)O- , $\text{-SO}_2\text{NR}^c\text{-}$, $\text{-SO}_2\text{O-}$, $\text{-P(O)(OR}^c\text{)O-}$, $\text{-P(O)(OR}^c\text{)NR}^c\text{-}$, $\text{-OP(O)(OR}^c\text{)O-}$, $\text{-OP(O)(OR}^c\text{)NR}^c\text{-}$, -OC(O)O- , $\text{-NR}^c\text{C(O)O-}$, $\text{-NR}^c\text{C(O)NR}^c\text{-}$, $\text{-OC(O)NR}^c\text{-}$ and $\text{-NR}^c\text{SO}_2\text{NR}^c\text{-}$;

Preferably, n is 0 or 1, and more preferably, n is 1.

Another preferred compound of the invention is a glycopeptide of formula II:



wherein:

R^{17} is a dicarboxy-substituted alkyl group having from 3 to 10 carbon atoms;

R^{18} is selected from the group consisting of hydrogen and alkyl;

5

R^{19} is hydrogen;

R^{20} is $-R^a-Y-R^b-(Z)_x$;

R^{21} is hydrogen;

R^a is selected from the group consisting of alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted alkynylene;

10

R^b is selected from the group consisting of a covalent bond, alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted alkynylene, provided R^b is not a covalent bond when Z is hydrogen;

Y is selected from the group consisting of sulfur, $-S(O)-$ and $-SO_2-$;

each Z is independently selected from hydrogen, aryl, cycloalkyl,

15

cycloalkenyl, heteroaryl and heterocyclic; and

x is 1 or 2;

or a pharmaceutically acceptable salt, or stereoisomer, or prodrug thereof.

For a compound of formula II, R^a is preferably selected from alkylene having from 1 to 10 carbon atoms. For example, R^a can be ethylene ($-\text{CH}_2\text{CH}_2-$), propylene ($-\text{CH}_2\text{CH}_2\text{CH}_2-$) or butylene ($-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-$).

For a compound of formula II, Z is preferably hydrogen and R^b is...
 5 alkylene of from 8 to 12 carbon atoms. More preferably, R^b can be a covalent bond, methylene, $-(\text{CH}_2)_6-$, $-(\text{CH}_2)_7-$, $-(\text{CH}_2)_8-$, $-(\text{CH}_2)_9-$ or $-(\text{CH}_2)_{10}-$.
 Additionally, R^b and Z can preferably form an *n*-octyl, *n*-nonyl, *n*-decyl, *n*-undecyl or *n*-dodecyl group.

For a compound of formula II, Z is preferably aryl, cycloalkyl,
 10 cycloalkenyl, heteroaryl and heterocyclic, and R^b is a covalent bond or alkylene of from 1 to 10 carbon atoms. More preferably, Z can be aryl. Preferred aryl groups include phenyl, substituted phenyl, biphenyl, substituted biphenyl and terphenyl groups. Most preferably, Z can be phenyl, 4-isobutylphenyl, 4'-chlorobiphenyl-4-yl, 4'-trifluoromethylbiphenyl-4-yl, 4-(naphth-2-yl)phenyl, 4-
 15 (2-phenylethynyl)phenyl, 4-(3,4-dichlorobenzyloxy)-phenyl, or *p*-terphenyl.

For a compound of formula II, x is preferably 1.

For a compound of formula II, Y is preferably sulfur.

For a compound of formula I or II, $-\text{R}^a-\text{Y}-\text{R}^b-(\text{Z})_x$ is preferably selected from the group consisting of: $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{CH}_3$;
 20 $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_{10}\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{CH}_3$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_3-\text{CH}=\text{CH}-(\text{CH}_2)_4\text{CH}_3$ (*trans*); $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_7\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}(\text{O})-(\text{CH}_2)_9\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_6\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{Ph}$;
 25 $-\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-(4\text{-Cl-Ph})-\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{S}(\text{O})-\text{CH}_2-4-(4\text{-Cl-Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-(4\text{-Cl-Ph})-\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}(\text{O})-\text{CH}_2-4-(4\text{-Cl-Ph})-\text{Ph}$;
 and $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-[3,4\text{-di-Cl-PhCH}_2\text{O-}]-\text{Ph}$. More preferably,
 $-\text{R}^a-\text{Y}-\text{R}^b-(\text{Z})_x$ is $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$.

For a compound of formula II, R^{17} is preferably a dicarboxy-substituted
 30 alkyl group having from 4 to 6 carbon atoms. More preferably R^{17} is $\text{CH}_2(\text{COOH})\text{CH}_2\text{COOH}$ or $-\text{CH}_2(\text{COOH})\text{CH}_2\text{CH}_2\text{COOH}$. Most preferably, R^{17} is $-\text{CH}_2(\text{COOH})\text{CH}_2\text{COOH}$.

For a compound of formula II, R^{18} is preferably hydrogen.

A preferred compound of formula II is a compound wherein
 $-R^a-Y-R^b-(Z)_x$ is $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$; R^{17} is $-\text{CH}_2(\text{COOH})\text{CH}_2\text{COOH}$;
 and R^{18} is hydrogen.

- A preferred value for R^{15} , R^{20} , or $-R^a-Y-R^b-(Z)_x$ is
- 5 $-\text{CH}_2\text{CH}_2-\text{NH}-(\text{CH}_2)_9\text{CH}_3$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NH}-(\text{CH}_2)_8\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-\text{NH}-(\text{CH}_2)_7\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{NHSO}_2-(\text{CH}_2)_9\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2-\text{NHSO}_2-(\text{CH}_2)_{11}\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_{10}\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{CH}_3$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$;
 - 10 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_3-\text{CH}=\text{CH}-(\text{CH}_2)_4\text{CH}_3$ (*trans*); $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_7\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2-\text{S}(\text{O})-(\text{CH}_2)_9\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_6\text{Ph}$;
 $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{NH}-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2-\text{NH}-\text{CH}_2-4-[4-(\text{CH}_3)_2\text{CHCH}_2-]-\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{NH}-\text{CH}_2-4-(4-\text{CF}_3-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{S}(\text{O})-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}(\text{O})-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-[3,4-\text{di-Cl-PhCH}_2\text{O-}]-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2-\text{NHSO}_2-\text{CH}_2-4-[4-(4-\text{Ph})-\text{Ph}]-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-\text{CH}_2-4-(\text{Ph}-\text{C}\equiv\text{C-})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$; or
 - 20 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-4-(\text{naphth-2-yl})-\text{Ph}$. Another preferred value for R^{15} or R^{20} is 4-(4-chlorophenyl)benzyl or 4-(4-chlorobenzoyloxy)benzyl.

The invention also provides a pharmaceutical composition comprising a pharmaceutically acceptable carrier and a therapeutically effective amount of a compound of the invention. In one preferred embodiment, the pharmaceutically acceptable carrier comprises an aqueous cyclodextrin solution. Preferably, the cyclodextrin is hydroxypropyl- β -cyclodextrin or sulfobutyl ether β -cyclodextrin. More preferably, the cyclodextrin is hydroxypropyl- β -cyclodextrin.

The compounds of the invention are highly effective antibacterial agents. Accordingly, the invention also provides a method of treating a mammal having a bacterial disease, comprising administering to the mammal a therapeutically effective amount of a compound of the invention. The invention also provides a method of treating a mammal having a bacterial disease, comprising

administering to the mammal a therapeutically effective amount of a pharmaceutical composition of the invention.

The invention also provides processes and intermediates useful for preparing compounds of the invention, which processes and intermediates are described further herein.

The invention also provides a compound of the invention as described herein for use in medical therapy, as well as the use of a compound of the invention in the manufacture of a formulation or medicament for treating a bacterial disease in a mammal.

Preferred compounds of the invention are the compounds of formula II shown in Table I below wherein R^{19} and R^{21} are each hydrogen.

Table I: Preferred Compounds of Formula II

| Compound | $NR^{17}R^{18}$ | R^{20} |
|----------|---|---------------------------------------|
| 1 | N-linked aspartic acid | $CH_3(CH_2)_9-$ |
| 2 | N-linked aspartic acid | $CH_3(CH_2)_{10}-$ |
| 3 | N-linked aspartic acid | $CH_3(CH_2)_{11}-$ |
| 4 | N-linked aspartic acid | $CH_3(CH_2)_{12}-$ |
| 5 | N-linked aspartic acid | $CH_3(CH_2)_9SCH_2CH_2-$ |
| 6 | Formula IV, wherein R^8 is N-(D-glucosamine). | $CH_3(CH_2)_9SCH_2CH_2-$ |
| 7 | N-linked aspartic acid | $CH_3(CH_2)_9OCH_2CH_2-$ |
| 8 | N-linked aspartic acid | 4-(4-chlorophenyl)benzyl |
| 9 | N-linked aspartic acid | 2-(4-(4-chlorophenyl)benzylthio)ethyl |
| 10 | N-linked aspartic acid | 2-(4-(4-chlorophenyl)benzyloxy)ethyl |
| 11 | N-linked aspartic acid | 4-(4'-chlorobiphenyl)butyl |
| 12 | N-linked glutamic acid | 4-(4-chlorophenyl)benzyl |
| 13 | N-linked glutamic acid | $CH_3(CH_2)_9NHCH_2CH_2-$ |
| 14 | Formula III, wherein R^8 is N-(D-glucamine) | $CH_3(CH_2)_9NHCH_2CH_2-$ |
| 15 | Formula III, wherein R^8 is N-(D-glucamine) | $CH_3(CH_2)_9OCH_2CH_2-$ |

Another preferred group of compounds of the invention are C-terminus polyacid derivatives of the glycopeptide antibiotic A82846B (also known as chloroorienticin A or LY264826). See for example R. Nagarajan et al., *J. Org. Chem.*, **1988**, *54*, 983-986; and N. Tsuji et al., *J. Antibiot.*, **1988**, *41*, 819-822.

- 5 The structure of this glycopeptide is similar to vancomycin, except A82846B contains an additional amino sugar (i.e. 4-epi-vancosamine attached at the R² position in formula I.) and further contains 4-epi-vancosamine in place of vancosamine in the disaccharide moiety attached at the R¹ position in formula I. For example, a preferred group of compounds are N-alkylated derivatives of
- 10 A82846B having a polyacid group at the C-terminus. N-alkylated derivatives of A82846B are known in the art and are described, for example, in U.S. Patent Number 5,840,684. C-Terminus polyacid derivatives of these compounds can readily be prepared using the procedures described herein.

- A particularly preferred group of compounds of the invention are
- 15 A82846B derivatives having a 4-(4-chlorophenyl)benzyl group or a 4-(4-chlorobenzoyloxy)benzyl group attached at the amino group of the 4-epi-vancosamine of the disaccharide moiety and having a group substituted at the C-terminus that comprises two or more carboxy group. Preferred polycarboxy substituents for A82846B derivatives include a nitrogen-linked aspartic acid, a
- 20 nitrogen linked glutamic acid, and a nitrogen-linked radical of formula III as described herein.

DETAILED DESCRIPTION OF THE INVENTION

- This invention relates to novel derivatives of glycopeptide antibiotics comprising a polyacid containing group at the C-terminus (compounds of the
- 25 invention), as well as to compositions comprising such compounds and to therapeutic methods comprising the administration of such compounds. When describing the compounds, compositions and methods of the invention, the following terms have the following meanings, unless otherwise indicated.

Definitions

The term "alkyl" refers to a monoradical branched or unbranched saturated hydrocarbon chain preferably having from 1 to 40 carbon atoms, more preferably 1 to 10 carbon atoms, and even more preferably 1 to 6 carbon atoms.

- 5 This term is exemplified by groups such as methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *iso*-butyl, *n*-hexyl, *n*-decyl, tetradecyl, and the like.

- The term "substituted alkyl" refers to an alkyl group as defined above, having from 1 to 8 substituents, preferably 1 to 5 substituents, and more preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, guanido, halogen, hydroxyl, keto, thioketo, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocycloxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl, -SO₂H, and -SO₂-heteroaryl.
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- The term "alkylene" refers to a diradical of a branched or unbranched saturated hydrocarbon chain, preferably having from 1 to 40 carbon atoms, preferably 1-10 carbon atoms, more preferably 1-6 carbon atoms. This term is exemplified by groups such as methylene (-CH₂-), ethylene (-CH₂CH₂-), the propylene isomers (e.g., -CH₂CH₂CH₂- and -CH(CH₃)CH₂-) and the like.
- 20

- The term "substituted alkylene" refers to an alkylene group, as defined above, having from 1 to 5 substituents, and preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, halogen, hydroxyl, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocycloxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl and -SO₂-heteroaryl. Additionally, such substituted alkylene groups include those where 2
- 25
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substituents on the alkylene group are fused to form one or more cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heterocyclic or heteroaryl groups fused to the alkylene group. Preferably such fused groups contain from 1 to 3 fused ring structures. Additionally, the term substituted
5 alkylene includes alkylene groups in which from 1 to 5 of the alkylene carbon atoms are replaced with oxygen, sulfur or -NR- where R is hydrogen or alkyl. Examples of substituted alkylenes are chloromethylene (-CH(Cl)-), aminoethylene (-CH(NH₂)CH₂-), 2-carboxypropylene isomers (-CH₂CH(CO₂H)CH₂-), ethoxyethyl (-CH₂CH₂ O-CH₂CH₂-) and the like.

10 The term "alkaryl" refers to the groups -alkylene-aryl and -substituted alkylene-aryl where alkylene, substituted alkylene and aryl are defined herein. Such alkaryl groups are exemplified by benzyl, phenethyl and the like.

The term "alkoxy" refers to the groups alkyl-O-, alkenyl-O-, cycloalkyl-O-, cycloalkenyl-O-, and alkynyl-O-, where alkyl, alkenyl, cycloalkyl,
15 cycloalkenyl, and alkynyl are as defined herein. Preferred alkoxy groups are alkyl-O- and include, by way of example, methoxy, ethoxy, *n*-propoxy, *iso*-propoxy, *n*-butoxy, *tert*-butoxy, *sec*-butoxy, *n*-pentoxy, *n*-hexoxy, 1,2-dimethylbutoxy, and the like.

The term "substituted alkoxy" refers to the groups substituted alkyl-O-,
20 substituted alkenyl-O-, substituted cycloalkyl-O-, substituted cycloalkenyl-O-, and substituted alkynyl-O- where substituted alkyl, substituted alkenyl, substituted cycloalkyl, substituted cycloalkenyl and substituted alkynyl are as defined herein.

The term "alkylalkoxy" refers to the groups -alkylene-O-alkyl,
25 alkylene-O-substituted alkyl, substituted alkylene-O-alkyl and substituted alkylene-O-substituted alkyl wherein alkyl, substituted alkyl, alkylene and substituted alkylene are as defined herein. Preferred alkylalkoxy groups are alkylene-O-alkyl and include, by way of example, methylenemethoxy (-CH₂OCH₃), ethylenemethoxy (-CH₂CH₂OCH₃), *n*-propylene-*iso*-propoxy (-CH₂CH₂CH₂OCH(CH₃)₂), methylene-*t*-butoxy (-CH₂-O-C(CH₃)₃) and the like.
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The term "alkylthioalkoxy" refers to the group -alkylene-S-alkyl, alkylene-S-substituted alkyl, substituted alkylene-S-alkyl and substituted alkylene-S-substituted alkyl wherein alkyl, substituted alkyl, alkylene and

substituted alkylene are as defined herein. Preferred alkylthioalkoxy groups are alkylene-S-alkyl and include, by way of example, methylenethiomethoxy ($-\text{CH}_2\text{SCH}_3$), ethylenethiomethoxy ($-\text{CH}_2\text{CH}_2\text{SCH}_3$), *n*-propylene-*iso*-thiopropoxy ($-\text{CH}_2\text{CH}_2\text{CH}_2\text{SCH}(\text{CH}_3)_2$), methylene-*t*-thiobutoxy ($-\text{CH}_2\text{SC}(\text{CH}_3)_3$) and the like.

The term "alkenyl" refers to a monoradical of a branched or unbranched unsaturated hydrocarbon group preferably having from 2 to 40 carbon atoms, more preferably 2 to 10 carbon atoms and even more preferably 2 to 6 carbon atoms and having at least 1 and preferably from 1-6 sites of vinyl unsaturation. Preferred alkenyl groups include ethenyl ($-\text{CH}=\text{CH}_2$), *n*-propenyl ($-\text{CH}_2\text{CH}=\text{CH}_2$), *iso*-propenyl ($-\text{C}(\text{CH}_3)=\text{CH}_2$), and the like.

The term "substituted alkenyl" refers to an alkenyl group as defined above having from 1 to 5 substituents, and preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, halogen, hydroxyl, keto, thioketo, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocycloxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl and -SO₂-heteroaryl.

The term "alkenylene" refers to a diradical of a branched or unbranched unsaturated hydrocarbon group preferably having from 2 to 40 carbon atoms, more preferably 2 to 10 carbon atoms and even more preferably 2 to 6 carbon atoms and having at least 1 and preferably from 1-6 sites of vinyl unsaturation. This term is exemplified by groups such as ethenylene ($-\text{CH}=\text{CH}-$), the propenylene isomers (e.g., $-\text{CH}_2\text{CH}=\text{CH}-$ and $-\text{C}(\text{CH}_3)=\text{CH}-$) and the like.

The term "substituted alkenylene" refers to an alkenylene group as defined above having from 1 to 5 substituents, and preferably from 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, substituted acyl, acylamino, substituted acylamino, acyloxy, substituted acyloxy, oxyamino, substituted oxyamino, amino, substituted amino, aminoacyl, substituted aminoacyl, aminoacyloxy, substituted aminoacyloxy, azido, cyano, halogen, hydroxyl, substituted hydroxyl, keto, substituted keto, thioketo, substituted thioketo, carboxy, substituted carboxy, carboxyalkyl, substituted carboxyalkyl, thioaryloxy, substituted thioaryloxy, thioheteroaryloxy, substituted thioheteroaryloxy, thioheterocycloxy, substituted thioheterocycloxy, thiol, substituted thiol, thioalkoxy, substituted thioalkoxy, aryl, substituted aryl, aryloxy, substituted aryloxy, heteroaryl, substituted heteroaryl, heteroaryloxy, substituted heteroaryloxy, heterocyclic, substituted heterocyclic, heterocycloxy, substituted heterocycloxy, hydroxyamino, substituted hydroxyamino, alkoxyamino, substituted alkoxyamino, nitro, substituted nitro, -SO-alkyl, substituted -SO-alkyl, -SO-substituted alkyl, substituted -SO-substituted alkyl, -SO-aryl, substituted -SO-aryl, -SO-heteroaryl, substituted -SO-heteroaryl, -SO₂-alkyl, substituted -SO₂-alkyl, -SO₂-substituted alkyl, substituted -SO₂-substituted alkyl, -SO₂-aryl, substituted -SO₂-aryl and -SO₂-heteroaryl, substituted -SO₂-heteroaryl.

acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, halogen, hydroxyl, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocyclooxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocyclooxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl and -SO₂-heteroaryl. Additionally, such substituted alkenylene groups include those where 2 substituents on the alkenylene group are fused to form one or more cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heterocyclic or heteroaryl groups fused to the alkenylene group.

The term "alkynyl" refers to a monoradical of an unsaturated hydrocarbon preferably having from 2 to 40 carbon atoms, more preferably 2 to 20 carbon atoms and even more preferably 2 to 6 carbon atoms and having at least 1 and preferably from 1-6 sites of acetylene (triple bond) unsaturation. Preferred alkynyl groups include ethynyl ($-C\equiv CH$), propargyl ($-CH_2C\equiv CH$) and the like.

The term "substituted alkynyl" refers to an alkynyl group as defined above having from 1 to 5 substituents, and preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, halogen, hydroxyl, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocyclooxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocyclooxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl and -SO₂-heteroaryl.

The term "alkynylene" refers to a diradical of an unsaturated hydrocarbon preferably having from 2 to 40 carbon atoms, more preferably 2 to 10 carbon atoms and even more preferably 2 to 6 carbon atoms and having at least 1 and preferably from 1-6 sites of acetylene (triple bond) unsaturation. Preferred alkynylene groups include ethynylene ($-C\equiv C-$), propargylene ($-CH_2C\equiv C-$) and the like.

The term "substituted alkynylene" refers to an alkynylene group as defined above having from 1 to 5 substituents, and preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, halogen, hydroxyl, keto, thioketo, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocycloxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl and -SO₂-heteroaryl

The term "acyl" refers to the groups HC(O)-, alkyl-C(O)-, substituted alkyl-C(O)-, cycloalkyl-C(O)-, substituted cycloalkyl-C(O)-, cycloalkenyl-C(O)-, substituted cycloalkenyl-C(O)-, aryl-C(O)-, heteroaryl-C(O)- and heterocyclic-C(O)- where alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic are as defined herein.

The term "acylamino" or "aminocarbonyl" refers to the group -C(O)NRR where each R is independently hydrogen, alkyl, substituted alkyl, aryl, heteroaryl, heterocyclic or where both R groups are joined to form a heterocyclic group (e.g., morpholino) wherein alkyl, substituted alkyl, aryl, heteroaryl and heterocyclic are as defined herein.

The term "aminoacyl" refers to the group -NRC(O)R where each R is independently hydrogen, alkyl, substituted alkyl, aryl, heteroaryl, or heterocyclic wherein alkyl, substituted alkyl, aryl, heteroaryl and heterocyclic are as defined herein.

The term "aminoacyloxy" or "alkoxycarbonylamino" refers to the group -NRC(O)OR where each R is independently hydrogen, alkyl, substituted alkyl, aryl, heteroaryl, or heterocyclic wherein alkyl, substituted alkyl, aryl, heteroaryl and heterocyclic are as defined herein.

The term "acyloxy" refers to the groups alkyl-C(O)O-, substituted alkyl-C(O)O-, cycloalkyl-C(O)O-, substituted cycloalkyl-C(O)O-, aryl-C(O)O-, heteroaryl-C(O)O-, and heterocyclic-C(O)O- wherein alkyl, substituted alkyl,

cycloalkyl, substituted cycloalkyl, aryl, heteroaryl, and heterocyclic are as defined herein.

The term "aryl" refers to an unsaturated aromatic carbocyclic group of from 6 to 20 carbon atoms having a single ring (e.g., phenyl) or multiple
5 condensed (fused) rings, wherein at least one ring is aromatic (e.g., naphthyl, dihydrophenanthrenyl, fluorenyl, or anthryl). Preferred aryls include phenyl, naphthyl and the like.

Unless otherwise constrained by the definition for the aryl substituent, such aryl groups can optionally be substituted with from 1 to 5 substituents,
10 preferably 1 to 3 substituents, selected from the group consisting of acyloxy, hydroxy, thiol, acyl, alkyl, alkoxy, alkenyl, alkynyl, cycloalkyl, cycloalkenyl, substituted alkyl, substituted alkoxy, substituted alkenyl, substituted alkynyl, substituted cycloalkyl, substituted cycloalkenyl, amino, substituted amino, aminoacyl, acylamino, alkaryl, aryl, aryloxy, azido, carboxy, carboxyalkyl,
15 cyano, halo, nitro, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, aminoacyloxy, oxyacylamino, sulfonamide, thioalkoxy, substituted thioalkoxy, thioaryloxy, thioheteroaryloxy, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl, -SO₂-heteroaryl and trihalomethyl. Preferred aryl substituents include alkyl, alkoxy, halo, cyano,
20 nitro, trihalomethyl, and thioalkoxy.

The term "aryloxy" refers to the group aryl-O- wherein the aryl group is as defined above including optionally substituted aryl groups as also defined above.

The term "arylene" refers to the diradical derived from aryl (including
25 substituted aryl) as defined above and is exemplified by 1,2-phenylene, 1,3-phenylene, 1,4-phenylene, 1,2-naphthylene and the like.

The term "amino" refers to the group -NH₂.

The term "substituted amino" refers to the group -NRR where each R is independently selected from the group consisting of hydrogen, alkyl, substituted
30 alkyl, cycloalkyl, substituted cycloalkyl, alkenyl, substituted alkenyl, cycloalkenyl, substituted cycloalkenyl, alkynyl, substituted alkynyl, aryl, heteroaryl and heterocyclic provided that both R's are not hydrogen.

"Amino acid" refers to any of the naturally occurring amino acids (e.g. Ala, Arg, Asn, Asp, Cys, Glu, Gln, Gly, His, Hyl, Hyp, Ile, Leu, Lys, Met, Phe, Pro, Ser, Thr, Trp, Tyr, and Val) in D, L, or DL form. The side chains of naturally occurring amino acids are well known in the art and include, for example, hydrogen (e.g., as in glycine), alkyl (e.g., as in alanine, valine, leucine, isoleucine, proline), substituted alkyl (e.g., as in threonine, serine, methionine, cysteine, aspartic acid, asparagine, glutamic acid, glutamine, arginine, and lysine), alkaryl (e.g., as in phenylalanine and tryptophan), substituted arylalkyl (e.g., as in tyrosine), and heteroarylalkyl (e.g., as in histidine).

10 The term "carboxy" refers to -COOH.

The term "C-terminus" as it relates to a glycopeptide is well understood in the art. For example, for a glycopeptide of formula I, the C-terminus is the position substituted by the group R³.

The term "dicarboxy-substituted alkyl" refers to an alkyl group substituted with two carboxy groups. This term includes, by way of example, -CH₂(COOH)-CH₂COOH and -CH₂(COOH)CH₂CH₂COOH.

The term "carboxyalkyl" or "alkoxycarbonyl" refers to the groups "-C(O)O-alkyl", "-C(O)O-substituted alkyl", "-C(O)O-cycloalkyl", "-C(O)O-substituted cycloalkyl", "-C(O)O-alkenyl", "-C(O)O-substituted alkenyl", "-C(O)O-alkynyl" and "-C(O)O-substituted alkynyl" where alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, alkenyl, substituted alkenyl, alkynyl and substituted alkynyl are as defined herein.

The term "cycloalkyl" refers to cyclic alkyl groups of from 3 to 20 carbon atoms having a single cyclic ring or multiple condensed rings. Such cycloalkyl groups include, by way of example, single ring structures such as cyclopropyl, cyclobutyl, cyclopentyl, cyclooctyl, and the like, or multiple ring structures such as adamantanyl, and the like.

The term "substituted cycloalkyl" refers to cycloalkyl groups having from 1 to 5 substituents, and preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano,

halogen, hydroxyl, keto, thioketo, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocycloxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl and -SO₂-heteroaryl.

The term "cycloalkenyl" refers to cyclic alkenyl groups of from 4 to 20 carbon atoms having a single cyclic ring and at least one point of internal unsaturation. Examples of suitable cycloalkenyl groups include, for instance, cyclobut-2-enyl, cyclopent-3-enyl, cyclooct-3-enyl and the like.

The term "substituted cycloalkenyl" refers to cycloalkenyl groups having from 1 to 5 substituents, and preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, halogen, hydroxyl, keto, thioketo, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocycloxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl and -SO₂-heteroaryl.

The term "halo" or "halogen" refers to fluoro, chloro, bromo and iodo.

"Haloalkyl" refers to alkyl as defined herein substituted by 1-4 halo groups as defined herein, which may be the same or different. Representative haloalkyl groups include, by way of example, trifluoromethyl, 3-fluorododecyl, 12,12,12-trifluorododecyl, 2-bromooctyl, 3-bromo-6-chloroheptyl, and the like.

The term "heteroaryl" refers to an aromatic group of from 1 to 15 carbon atoms and 1 to 4 heteroatoms selected from oxygen, nitrogen and sulfur within at least one ring (if there is more than one ring).

Unless otherwise constrained by the definition for the heteroaryl substituent, such heteroaryl groups can be optionally substituted with 1 to 5 substituents, preferably 1 to 3 substituents, selected from the group consisting of acyloxy, hydroxy, thiol, acyl, alkyl, alkoxy, alkenyl, alkynyl, cycloalkyl, cycloalkenyl, substituted alkyl, substituted alkoxy, substituted alkenyl, substituted alkynyl, substituted cycloalkyl, substituted cycloalkenyl, amino,

substituted amino, aminoacyl, acylamino, alkaryl, aryl, aryloxy, azido, carboxy, carboxyalkyl, cyano, halo, nitro, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, aminoacyloxy, oxyacylamino, thioalkoxy, substituted thioalkoxy, thioaryloxy, thioheteroaryloxy, -SO-alkyl, -SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-heteroaryl and trihalomethyl. Preferred aryl substituents include alkyl, alkoxy, halo, cyano, nitro, trihalomethyl, and thioalkoxy. Such heteroaryl groups can have a single ring (e.g., pyridyl or furyl) or multiple condensed rings (e.g., indolizinyl or benzothieryl). Preferred heteroaryls include pyridyl, pyrrolyl and furyl.

"Heteroarylalkyl" refers to (heteroaryl)alkyl- where heteroaryl and alkyl are as defined herein. Representative examples include 2-pyridylmethyl and the like.

The term "heteroaryloxy" refers to the group heteroaryl-O-.

The term "heteroarylene" refers to the diradical group derived from heteroaryl (including substituted heteroaryl), as defined above, and is exemplified by the groups 2,6-pyridylene, 2,4-pyridylene, 1,2-quinolinyne, 1,8-quinolinyne, 1,4-benzofuranylene, 2,5-pyridylene, 2,5-indolenyl and the like.

The term "heterocycle" or "heterocyclic" refers to a monoradical saturated or unsaturated group having a single ring or multiple condensed rings, from 1 to 40 carbon atoms and from 1 to 10 hetero atoms, preferably 1 to 4 heteroatoms, selected from nitrogen, sulfur, phosphorus, and/or oxygen within the ring.

Unless otherwise constrained by the definition for the heterocyclic substituent, such heterocyclic groups can be optionally substituted with 1 to 5, and preferably 1 to 3 substituents, selected from the group consisting of alkoxy, substituted alkoxy, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, acyl, acylamino, acyloxy, amino, substituted amino, aminoacyl, aminoacyloxy, oxyaminoacyl, azido, cyano, halogen, hydroxyl, keto, thioketo, carboxy, carboxyalkyl, thioaryloxy, thioheteroaryloxy, thioheterocycloxy, thiol, thioalkoxy, substituted thioalkoxy, aryl, aryloxy, heteroaryl, heteroaryloxy, heterocyclic, heterocycloxy, hydroxyamino, alkoxyamino, nitro, -SO-alkyl, -

SO-substituted alkyl, -SO-aryl, -SO-heteroaryl, -SO₂-alkyl, -SO₂-substituted alkyl, -SO₂-aryl, oxo (O=), and -SO₂-heteroaryl. Such heterocyclic groups can have a single ring or multiple condensed rings. Preferred heterocyclics include morpholino, piperidiny, and the like.

5 Examples of nitrogen heterocycles and heteroaryls include, but are not limited to, pyrrole, imidazole, pyrazole, pyridine, pyrazine, pyrimidine, pyridazine, indolizine, isoindole, indole, indazole, purine, quinolizine, isoquinoline, quinoline, phthalazine, naphthylpyridine, quinoxaline, quinazoline, cinnoline, pteridine, carbazole, carboline, phenanthridine, acridine,
10 phenanthroline, isothiazole, phenazine, isoxazole, phenoxazine, phenothiazine, imidazolidine, imidazoline, piperidine, piperazine, indoline, morpholino, piperidiny, tetrahydrofurany, and the like as well as N-alkoxy-nitrogen containing heterocycles.

Another class of heterocyclics is known as "crown compounds" which
15 refers to a specific class of heterocyclic compounds having one or more repeating units of the formula $[-(\text{CH}_2)_a\text{A}-]$ where a is equal to or greater than 2, and A at each separate occurrence can be O, N, S or P. Examples of crown compounds include, by way of example only, $[-(\text{CH}_2)_3\text{-NH-}]_3$, $[-((\text{CH}_2)_2\text{-O})_4\text{-}((\text{CH}_2)_2\text{-NH})_2]$ and the like. Typically such crown compounds can have from 4
20 to 10 heteroatoms and 8 to 40 carbon atoms.

The term "heterocyclooxy" refers to the group heterocyclic-O-.

The term "thioheterocyclooxy" refers to the group heterocyclic-S-.

The term "oxyacylamino" or "aminocarbonyloxy" refers to the group
-OC(O)NRR where each R is independently hydrogen, alkyl, substituted alkyl,
25 aryl, heteroaryl, or heterocyclic wherein alkyl, substituted alkyl, aryl, heteroaryl and heterocyclic are as defined herein.

The term "prodrug" is well understood in the art and includes compounds that are converted to pharmaceutically active compounds of the invention in a mammalian system. For example, see *Remington's Pharmaceutical Sciences*,
30 1980, vol. 16, Mack Publishing Company, Easton, Pennsylvania, 61 and 424.

The term "saccharide group" refers to an oxidized, reduced or substituted saccharide monoradical covalently attached to the glycopeptide or other compound via any atom of the saccharide moiety, preferably via the aglycone

carbon atom. The term includes amino-containing saccharide groups.

Representative saccharides include, by way of illustration, hexoses such as D-glucose, D-mannose, D-xylose, D-galactose, vancosamine, 3-desmethyl-vancosamine, 3-epi-vancosamine, 4-epi-vancosamine, acosamine, actinosamine, 5 daunosamine, 3-epi-daunosamine, ristosamine, D-glucamine, N-methyl-D-glucamine, D-glucuronic acid, N-acetyl-D-glucosamine, N-acetyl-D-galactosamine, sialic acid, iduronic acid, L-fucose, and the like; pentoses such as D-ribose or D-arabinose; ketoses such as D-ribulose or D-fructose; disaccharides such as 2-O-(α -L-vancosaminyl)- β -D-glucopyranose, 2-O-(3- 10 desmethyl- α -L-vancosaminyl)- β -D-glucopyranose, sucrose, lactose, or maltose; derivatives such as acetals, amines, acylated, sulfated and phosphorylated sugars; oligosaccharides having from 2 to 10 saccharide units. For the purposes of this definition, these saccharides are referenced using conventional three letter nomenclature and the saccharides can be either in their open or preferably in 15 their pyranose form.

The term "amino-containing saccharide group" or "amino saccharide" refers to a saccharide group having an amino substituent. Representative amino-containing saccharides include L-vancosamine, 3-desmethyl-vancosamine, 3-epi-vancosamine, 4-epi-vancosamine, acosamine, actinosamine, daunosamine, 3-epi- 20 daunosamine, ristosamine, N-methyl-D-glucamine and the like.

The term "spiro-attached cycloalkyl group" refers to a cycloalkyl group attached to another ring via one carbon atom common to both rings.

The term "stereoisomer" as it relates to a given compound is well understood in the art, and refers another compound having the same molecular 25 formula, wherein the atoms making up the other compound differ in the way they are oriented in space, but wherein the atoms in the other compound are like the atoms in the given compound with respect to which atoms are joined to which other atoms (e.g. an enantiomer, a diastereomer, or a geometric isomer). See for example, *Morrison and Boyde Organic Chemistry*, 1983, 4th ed., Allyn 30 and Bacon, Inc., Boston, Mass., page 123

The term "sulfonamide" refers to a group of the formula $-\text{SO}_2\text{NRR}$, where each R is independently hydrogen, alkyl, substituted alkyl, aryl,

heteroaryl, or heterocyclic wherein alkyl, substituted alkyl, aryl, heteroaryl and heterocyclic are as defined herein.

The term "thiol" refers to the group -SH.

The term "thioalkoxy" refers to the group -S-alkyl.

5 The term "substituted thioalkoxy" refers to the group -S-substituted alkyl.

The term "thioaryloxy" refers to the group aryl-S- wherein the aryl group is as defined above including optionally substituted aryl groups also defined above.

10 The term "thioheteroaryloxy" refers to the group heteroaryl-S- wherein the heteroaryl group is as defined above including optionally substituted aryl groups as also defined above.

The term "thioether derivatives" when used to refer to the glycopeptide compounds of this invention includes thioethers (-S-), sulfoxides (-SO-) and sulfones (-SO₂-).

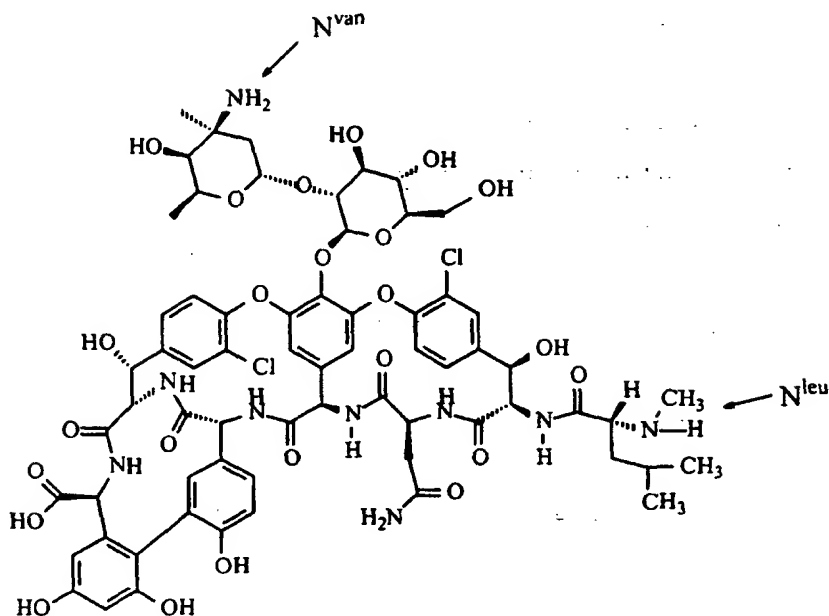
15 As to any of the above groups which contain one or more substituents, it is understood, of course, that such groups do not contain any substitution or substitution patterns which are sterically impractical and/or synthetically non-feasible. In addition, the compounds of this invention include all stereochemical isomers arising from the substitution of these compounds.

20 "Cyclodextrin" refers to cyclic molecules containing six or more α -D-glucopyranose units linked at the 1,4 positions by α linkages as in amylose. β -Cyclodextrin or cycloheptaamylose contains seven α -D-glucopyranose units. As used herein, the term "cyclodextrin" also includes cyclodextrin derivatives such as hydroxypropyl and sulfobutyl ether cyclodextrins. Such derivatives are
25 described for example, in U.S. Patent Nos. 4,727,064 and 5,376,645. One preferred cyclodextrin is hydroxypropyl β -cyclodextrin having a degree of substitution of from about 4.1-5.1 as measured by FTIR. Such a cyclodextrin is available from Cerestar (Hammond, Indiana, USA) under the name Cavitron™ 82003.

30 "Glycopeptide" refers to oligopeptide (e.g. a heptapeptide) antibiotic, characterized by a multi-ring peptide core optionally substituted with saccharide groups, such as vancomycin. Examples of glycopeptides included in this definition may be found in "Glycopeptides Classification, Occurrence, and

Discovery", by Raymond C. Rao and Louise W. Crandall, ("Drugs and the Pharmaceutical Sciences" Volume 63, edited by Ramakrishnan Nagarajan, published by Marcel Dekker, Inc.). Additional examples of glycopeptodes are disclosed in U.S. Patent Nos. 4,639,433; 4,643,987; 4,497,802; 4,698,327; 5,591,714; 5,840,684; and 5,843,889; in EP 0 802 199; EP 0 801 075; EP 0 667 353; WO 97/28812; WO 97/38702; WO 98/52589; WO 98/52592; and in *J. Amer. Chem. Soc.*, 1996, 118, 13107-13108; *J. Amer. Chem. Soc.*, 1997, 119, 12041-12047; and *J. Amer. Chem. Soc.*, 1994, 116, 4573-4590. Representative glycopeptides include those identified as A477, A35512, A40926, A41030, A42867, A47934, A80407, A82846, A83850, A84575, AB-65, Actaplanin, Actinoidin, Ardacin, Avoparcin, Azureomycin, Balhimycin, Chloroorientein, Chloropolysporin, Decaplanin, *N*-demethyl-vancomycin, Eremomycin, Galacardin, Helvecardin, Izupeptin, Kibdelin, LL-AM374, Mannopeptin, MM45289, MM47756, MM47761, MM49721, MM47766, MM55260, MM55266, MM55270, MM56597, MM56598, OA-7653, Orenticin, Parvodicin, Ristocetin, Ristomycin, Synmonicin, Teicoplanin, UK-68597, UK-69542, UK-72051, Vancomycin, and the like. The term "glycopeptide" as used herein is also intended to include the general class of peptides disclosed above on which the sugar moiety is absent, i.e. the aglycone series of glycopeptides. For example, removal of the disaccharide moiety appended to the phenol on vancomycin by mild hydrolysis gives vancomycin aglycone. Also within the scope of the invention are glycopeptides that have been further appended with additional saccharide residues, especially aminoglycosides, in a manner similar to vancosamine.

"Vancomycin" refers to a glycopeptide antibiotic having the formula:



When describing vancomycin derivatives, the term "N^{van}-" indicates that a substituent is covalently attached to the amino group of the vancosamine moiety of vancomycin. Similarly, the term "N^{leu}-" indicates that a substituent is covalently attached to the amino group of the leucine moiety of vancomycin.

"Optional" or "optionally" means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where said event or circumstance occurs and instances in which it does not. For example, "optionally substituted" means that a group may or may not be substituted with the described substituent.

As used herein, the terms "inert organic solvent" or "inert solvent" or "inert diluent" mean a solvent or diluent which is essentially inert under the conditions of the reaction in which it is employed as a solvent or diluent. Representative examples of materials which may be used as inert solvents or diluents include, by way of illustration, benzene, toluene, acetonitrile, tetrahydrofuran ("THF"), dimethylformamide ("DMF"), chloroform ("CHCl₃"), methylene chloride (or dichloromethane or "CH₂Cl₂"), diethyl ether, ethyl acetate, acetone, methylethyl ketone, methanol, ethanol, propanol, isopropanol,

tert-butanol, dioxane, pyridine, and the like. Unless specified to the contrary, the solvents used in the reactions of the present invention are inert solvents.

"Pharmaceutically acceptable salt" means those salts which retain the biological effectiveness and properties of the parent compounds and which are not biologically or otherwise harmful as the dosage administered. The compounds of this invention are capable of forming both acid and base salts by virtue of the presence of amino and carboxy groups respectively.

The term "nitrogen-linked" or "N-linked" means a group or substituent is attached to the remainder of a compound (e.g. a compound of formula I) through a bond to a nitrogen of the group or substituent. The term "oxygen-linked" means a group or substituent is attached to the remainder of a compound (e.g. a compound of formula I) through a bond to an oxygen of the group or substituent. The term "sulfur-linked" means a group or substituent is attached to the remainder of a compound (e.g. a compound of formula I) through a bond to a sulfur of the group or substituent.

Pharmaceutically acceptable base addition salts may be prepared from inorganic and organic bases. Salts derived from inorganic bases include, but are not limited to, the sodium, potassium, lithium, ammonium, calcium, and magnesium salts. Salts derived from organic bases include, but are not limited to, salts of primary, secondary and tertiary amines, substituted amines including naturally-occurring substituted amines, and cyclic amines, including isopropylamine, trimethyl amine, diethylamine, triethylamine, tripropylamine, ethanolamine, 2-dimethylaminoethanol, tromethamine, lysine, arginine, histidine, caffeine, procaine, hydrabamine, choline, betaine, ethylenediamine, glucosamine, N-alkylglucamines, theobromine, purines, piperazine, piperidine, and N-ethylpiperidine. It should also be understood that other carboxylic acid derivatives would be useful in the practice of this invention, for example carboxylic acid amides, including carboxamides, lower alkyl carboxamides, di(lower alkyl) carboxamides, and the like.

Pharmaceutically acceptable acid addition salts may be prepared from inorganic and organic acids. Salts derived from inorganic acids include hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid and the like. Salts derived from organic acids include acetic acid, propionic acid,

glycolic acid, pyruvic acid, oxalic acid, malic acid, malonic acid, succinic acid, maleic acid, fumaric acid, tartaric acid, citric acid, benzoic acid, cinnamic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, p-toluenesulfonic acid, salicylic acid and the like.

5 The compounds of this invention typically contain one or more chiral centers. Accordingly, this invention is intended to include racemic mixtures, diastereomers, enantiomers and mixture enriched in one or more stereoisomer. The scope of the invention as described and claimed encompasses the racemic forms of the compounds as well as the individual enantiomers and non-racemic
10 mixtures thereof.

 The term "treatment" as used herein includes any treatment of a condition or disease in an animal, particularly a mammal, more particularly a human, and includes:

- (i) preventing the disease or condition from occurring in a subject
15 which may be predisposed to the disease but has not yet been diagnosed as having it;
- (ii) inhibiting the disease or condition, i.e. arresting its development; relieving the disease or condition, i.e. causing regression of the condition; or relieving the conditions caused by the disease, i.e. symptoms of the disease.

20 The term "disease state which is alleviated by treatment with a broad spectrum antibacterial" or "bacterial disease" as used herein is intended to cover all disease states which are generally acknowledged in the art to be usefully treated with a broad spectrum antibacterial in general, and those disease states which have been found to be usefully treated by the specific antibacterials of this
25 invention. Such disease states include, but are not limited to, treatment of a mammal afflicted with pathogenic bacteria, in particular staphylococci (methicillin sensitive and resistant), streptococci (penicillin sensitive and resistant), enterococci (vancomycin sensitive and resistant), and *Clostridium difficile*

30 The term "therapeutically effective amount" refers to that amount which is sufficient to effect treatment, as defined herein, when administered to a mammal in need of such treatment. The therapeutically effective amount will vary depending on the subject and disease state being treated, the severity of the

affliction and the manner of administration, and may be determined routinely by one of ordinary skill in the art.

The term "protecting group" or "blocking group" refers to any group which, when bound to one or more hydroxyl, thiol, amino, carboxy or other groups of the compounds, prevents undesired reactions from occurring at these groups and which protecting group can be removed by conventional chemical or enzymatic steps to reestablish the hydroxyl, thio, amino, carboxy or other group. The particular removable blocking group employed is not critical and preferred removable hydroxyl blocking groups include conventional substituents such as allyl, benzyl, acetyl, chloroacetyl, thiobenzyl, benzyldine, phenacyl, *t*-butyl-diphenylsilyl and any other group that can be introduced chemically onto a hydroxyl functionality and later selectively removed either by chemical or enzymatic methods in mild conditions compatible with the nature of the product. Protecting groups are disclosed in more detail in T.W. Greene and P.G.M. Wuts, "Protective Groups in Organic Synthesis" 3rd Ed., 1999, John Wiley and Sons, N.Y.

Preferred removable amino blocking groups include conventional substituents such as *t*-butoxycarbonyl (t-BOC), benzyloxycarbonyl (CBZ), fluorenylmethoxycarbonyl (Fmoc), allyloxycarbonyl (ALOC) and the like, which can be removed by conventional conditions compatible with the nature of the product.

Preferred carboxy protecting groups include esters such as methyl, ethyl, propyl, *t*-butyl etc. which can be removed by mild conditions compatible with the nature of the product.

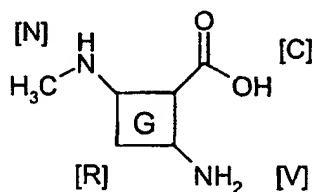
General Synthetic Procedures

The glycopeptide compounds of this invention can be prepared from readily available starting materials using the following general methods and procedures. It will be appreciated that where typical or preferred process conditions (i.e., reaction temperatures, times, mole ratios of reactants, solvents, pressures, etc.) are given, other process conditions can also be used unless otherwise stated. Optimum reaction conditions may vary with the particular

reactants or solvent used, but such conditions can be determined by one skilled in the art by routine optimization procedures.

Additionally, as will be apparent to those skilled in the art, conventional protecting groups may be necessary to prevent certain functional groups from undergoing undesired reactions. The choice of a suitable protecting group for a particular functional group as well as suitable conditions for protection and deprotection are well known in the art. For example, numerous protecting groups, and their introduction and removal, are described in T. W. Greene and G. M. Wuts, *Protecting Groups in Organic Synthesis*, Third Edition, Wiley, New York, 1999, and references cited therein.

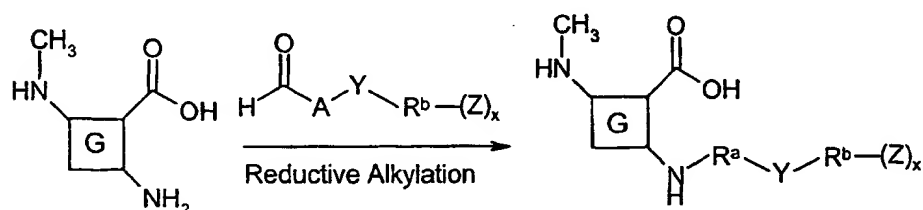
In the following reaction schemes, the glycopeptide compounds are depicted in a simplified form as a box "G" that shows the carboxy terminus labeled [C], the vancosamine amino terminus labeled [V], the "non-saccharide" amino terminus (leucine amine moiety) labeled [N], and optionally, the resorcinol moiety labeled [R] as follows:



A glycopeptide compound of the present invention that is substituted at the C-terminus with a substituent that comprises two or more carboxy groups can be prepared by coupling the corresponding glycopeptide compound wherein the C-terminus is a carboxy group with the requisite carboxy-protected compound. Subsequent removal of the carboxy protecting groups affords the compound of the invention. For example a glycopeptide compound of formula I wherein R³ is a nitrogen linked moiety comprising two or more carboxy groups can be prepared by coupling a corresponding glycopeptide compound of formula I wherein R³ is hydroxy with the requisite carboxy-protected amine to form an amide. Subsequent removal of the carboxy protecting groups affords the compound of the invention.

A glycopeptide compound of the present invention wherein the C-terminus is substituted with a substituent that comprises two or more carboxy groups and wherein the vancosamine amino terminus (V) is also substituted, can be prepared by first reductively alkylating the corresponding glycopeptide compound wherein the vancosamine amino terminus (V) is the free amine (NH₂) and then coupling the corresponding glycopeptide compound with the requisite poly carboxy-protected compound at the C-terminus. Subsequent removal of the carboxy protecting groups affords the compound of the invention.

By way of illustration, a glycopeptide compound, such as vancomycin, can first be reductive alkylated as shown in the following reaction:



where A represents R^a minus one carbon atom and R^a, R^b, Y, Z and x are as defined herein. This reaction is typically conducted by first contacting one equivalent of the glycopeptide, i.e., vancomycin, with an excess, preferably from 1.1 to 1.3 equivalents, of the desired aldehyde in the presence of an excess, preferably about 2.0 equivalents, of a tertiary amine, such as diisopropylethylamine (DIPEA) and the like. This reaction is typically conducted in an inert diluent, such as DMF or acetonitrile/water, at ambient temperature for about 0.25 to 2 hours until formation of the corresponding imine and/or hemiaminal is substantially complete. The resulting imine and/or hemiaminal is typically not isolated, but is reacted *in situ* with a metal hydride reducing agent, such as sodium cyanoborohydride and the like, to afford the corresponding amine. This reaction is preferably conducted by contacting the imine and/or hemiaminal with an excess, preferably about 3 equivalents, of trifluoroacetic acid, followed by about 1 to 1.2 equivalents of the reducing agent at ambient temperature in methanol or acetonitrile/water. The resulting alkylated product is readily purified by conventional procedures, such as precipitation

and/or reverse-phase HPLC. Surprisingly, by forming the imine and/or hemiaminal in the presence of a trialkyl amine, and then acidifying with trifluoroacetic acid before contact with the reducing agent, the selectivity for the reductive alkylation reaction is greatly improved, i.e., reductive alkylation at the amino group of the saccharide (e.g., vancosamine) is favored over reductive alkylation at the N-terminus (e.g., the leuciny group) by at least 10:1, more preferably 20:1.

The above process is a significantly improvement over previous methods for selectively alkylating an amino saccharide group of a glycopeptide antibiotic. Thus, the present invention also provides a method for alkylating a glycopeptide that comprises a saccharide-amine comprising:

combining an aldehyde or ketone, a suitable base, and the glycopeptide, to provide a reaction mixture;
acidifying the reaction mixture; and
combining the reaction mixture with a suitable reducing agent, to provide a glycopeptide that is alkylated at the saccharide-amine. Preferably, the glycopeptide comprises at least one amino group other than the saccharide-amine.

Preferably, the reductive alkylation at the saccharide-amine is favored over reductive alkylation at another amino group of the glycopeptide by at least about 10:1; and more preferably, by at least about 15:1 or about 20:1.

The reductive alkylation process of the invention is typically carried out in the presence of a suitable solvent or combination of solvents, such as, for example, a halogenated hydrocarbon (e.g. methylene chloride), a linear or branched ether (e.g. diethyl ether, tetrahydrofuran), an aromatic hydrocarbon (e.g. benzene or toluene), an alcohol (methanol, ethanol, or isopropanol), dimethylsulfoxide (DMSO), N,N-dimethylformamide, acetonitrile, water, 1,3-dimethyl-3,4,5,6-tetrahydro-2(1H)-pyrimidone, tetramethyl urea, N,N-dimethylacetamide, diethylformamide (DMF), 1-methyl-2-pyrrolidinone, tetramethylenesulfoxide, glycerol, ethyl acetate, isopropyl acetate, N,N-dimethylpropylene urea (DMPU) or dioxane. Preferably the alkylation is carried out in acetonitrile/water, or DMF/methanol.

Preferably the reduction (i.e. treatment with the reducing agent) is carried out in the presence of a protic solvent, such as, for example, an alcohol (e.g. methanol, ethanol, propanol, isopropanol, or butanol), water, or the like.

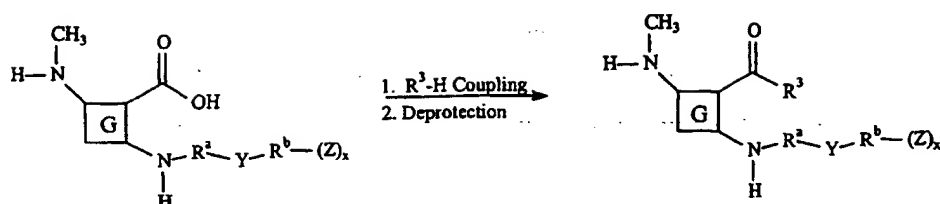
5 The reductive alkylation process of the invention can be carried out at any suitable temperature from the freezing point to the reflux temperature of the reaction mixture. Preferably the reaction is carried out at a temperature in the range of about 0 °C to about 100 °C. More preferably at a temperature in a range of about 0 °C to about 50 °C, or in a range of about 20 °C to about 30 °C.

10 Any suitable base can be employed in the reductive alkylation process of the invention. Suitable bases include tertiary amines (e.g. diisopropylethylamine, N-methylmorpholine or triethylamine) and the like.

Any suitable acid can be used to acidify the reaction mixture. Suitable acids include carboxylic acids (e.g. acetic acid, trichloroacetic acid, citric acid, formic acid, or trifluoroacetic acid), mineral acids (e.g. hydrochloric acid, 15 sulfuric acid, or phosphoric acid), and the like. A preferred acid is trifluoroacetic acid.

Suitable reducing agents for carrying out reductive alkylation process of the invention are known in the art. Any suitable reducing agent can be employed in the methods of the invention, provided it is compatible with the functionality 20 present in the glycopeptide. For example, suitable reducing agents include sodium cyanoborohydride, triacetoxyborohydride, pyridine/borane, sodium borohydride, and zinc borohydride. The reduction can also be carried out in the presence of a transition metal catalyst (e.g. palladium or platinum) in the presence of a hydrogen source (e.g. hydrogen gas or cyclohexadiene). See for 25 example, , *Advanced Organic Chemistry*, Fourth Edition, John Wiley & Sons, New York (1992), 899-900.

The glycopeptide derivative resulting from the reductive alkylation can then coupled with a polycarboxy-substituted amine (R^3-H) to form an amide. This reaction is illustrated by the following reaction:



where R^3 is a nitrogen-linked group that comprises at least two protected carboxy groups. In this reaction, the glycopeptide derivative is typically contacted with the amine in the presence of a peptide coupling reagent, such as PyBOP and HOBT, to provide the amide. This reaction is typically conducted in an inert diluent, such as DMF, at a temperature ranging from about 0°C to about 60°C for about 1 to 24 hours or until the coupling reaction is substantially complete. Subsequent deprotection using conventional procedures and reagents affords the compound of this invention.

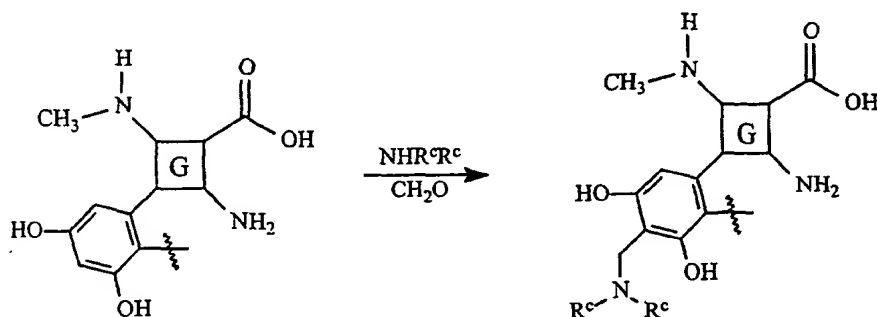
If desired, the amine coupling step described above can be conducted first to provide an amide, followed by reductive alkylation and deprotection to afford the compound of the invention.

If desired, the glycopeptide compounds of this invention can also be prepared in a step-wise manner in which a precursor to the $-\text{R}^a-\text{Y}-\text{R}^b-(\text{Z})_x$ group is first attached to the glycopeptide by reductive alkylation, followed by subsequent elaboration of the attached precursor using conventional reagent and procedures to form the $-\text{R}^a-\text{Y}-\text{R}^b-(\text{Z})_x$ group. Additionally, ketones may also be employed in the above-described reductive alkylation reactions to afford α -substituted amines.

Any glycopeptide having an amino group may be employed in these reductive alkylation reactions. Such glycopeptides are well-known in the art and are either commercially available or may be isolated using conventional procedures. Suitable glycopeptides are disclosed, by way of example, in U.S. Patent Nos. 3,067,099; 3,338,786; 3,803,306; 3,928,571; 3,952,095; 4,029,769; 4,051,237; 4,064,233; 4,122,168; 4,239,751; 4,303,646; 4,322,343; 4,378,348; 4,497,802; 4,504,467; 4,542,018; 4,547,488; 4,548,925; 4,548,974; 4,552,701; 4,558,008; 4,639,433; 4,643,987; 4,661,470; 4,694,069; 4,698,327; 4,782,042; 4,914,187; 4,935,238; 4,946,941; 4,994,555; 4,996,148; 5,187,082; 5,192,742;

5,312,738; 5,451,570; 5,591,714; 5,721,208; 5,750,509; 5,840,684; and 5,843,889. Preferably, the glycopeptide employed in the above reaction is vancomycin.

- As illustrated in the following scheme, an aminoalkyl sidechain at the resorcinol moiety of a glycopeptide, such as vancomycin, can be introduced via a Mannich reaction (in this scheme, the resorcinol moiety is shown for clarity). In this reaction, an amine (NHR^c) and an aldehyde (CH_2O), such as formalin (a source of formaldehyde), are reacted with the glycopeptide under basic conditions to give the glycopeptide derivative.



- Compounds of the invention comprising a sulfoxide or sulfone can be prepared from the corresponding thio compounds using conventional reagents and procedures. Suitable reagents for oxidizing a thio compound to a sulfoxide include, by way of example, hydrogen peroxide, peracides such as 3-chloroperoxybenzoic acid (MCPBA), sodium periodate, sodium chlorite, sodium hypochlorite, calcium hypochlorite, tert-butyl hypochlorite and the like. Chiral oxidizing reagents, (optically active reagents) may also be employed to provide chiral sulfoxides. Such optically active reagents are well-known in the art and include, for example, the reagents described in Kagen et al., *Synlett.*, 1990, 643-650.

- The aldehydes and ketones employed in the above reactive alkylation reactions are also well-known in the art and are either commercially available or can be prepared by conventional procedures using commercially available starting materials and conventional reagents (for example see March, *Advanced*

Organic Chemistry, Fourth Edition, John Wiley & Sons, New York (1992), and references cited therein).

The poly-carboxy-substituted compounds (e.g. poly-carboxy-substituted amines, alcohols, and thiols) employed to prepare the compounds of the invention are either commercially available or can be prepared by conventional procedures using commercially available starting materials and reagents. For example, the amino polyacids L-aspartic acid, D-aspartic acid, DL-aspartic acid, N-methyl-D-aspartic acid, L-glutamic acid, D-glutamic acid, D,L-glutamic acid, DL-2-methylglutamic acid, DL-2-aminoadipic acid, D-2-aminoadipic acid, L-2-aminoadipic acid, 3-aminoadipic acid, 2,6-diaminopimelic acid, L-gamma-carboxyglutamic acid, lanthionine, D-cystine, L-cystine, iminodiacetic acid, ethylenediamine-N,N'-diacetic acid, and kainic acid, as well as numerous biscarboxy-protected derivatives of L-aspartic acid and L-glutamic acid are commercially available from Sigma, St. Louis, MO and Aldrich Chemical Company, Milwaukee, WI. Other biscarboxy-protected derivatives of L-aspartic acid and the like, such as the bis-fluorenylmethyl esters, are readily prepared using well-known procedures and reagents.

Additional details and other methods for preparing the compounds of this invention are described in the Examples below.

20 Pharmaceutical Compositions

This invention also includes pharmaceutical composition containing the novel glycopeptide compounds of this invention. Accordingly, the glycopeptide compound, preferably in the form of a pharmaceutically acceptable salt, can be formulated for oral or parenteral administration for the therapeutic or prophylactic treatment of bacterial infections.

By way of illustration, the glycopeptide compound can be admixed with conventional pharmaceutical carriers and excipients and used in the form of tablets, capsules, elixirs, suspensions, syrups, wafers, and the like. Such pharmaceutical compositions will contain from about 0.1 to about 90% by weight of the active compound, and more generally from about 10 to about 30%. The pharmaceutical compositions may contain common carriers and excipients, such as corn starch or gelatin, lactose, sucrose, microcrystalline cellulose, kaolin,

mannitol, dicalcium phosphate, sodium chloride, and alginic acid. Disintegrators commonly used in the formulations of this invention include croscarmellose, microcrystalline cellulose, corn starch, sodium starch glycolate and alginic acid.

5 A liquid composition will generally consist of a suspension or solution of the compound or pharmaceutically acceptable salt in a suitable liquid carrier(s), for example ethanol, glycerine, sorbitol, non-aqueous solvent such as polyethylene glycol, oils or water, optionally with a suspending agent, a solubilizing agent (such as a cyclodextrin), preservative, surfactant, wetting agent, flavoring or coloring agent. Alternatively, a liquid formulation can be
10 prepared from a reconstitutable powder.

For example a powder containing active compound, suspending agent, sucrose and a sweetener can be reconstituted with water to form a suspension; and a syrup can be prepared from a powder containing active ingredient, sucrose and a sweetener.

15 A composition in the form of a tablet can be prepared using any suitable pharmaceutical carrier(s) routinely used for preparing solid compositions. Examples of such carriers include magnesium stearate, starch, lactose, sucrose, microcrystalline cellulose and binders, for example polyvinylpyrrolidone. The tablet can also be provided with a color film coating, or color included as part of
20 the carrier(s). In addition, active compound can be formulated in a controlled release dosage form as a tablet comprising a hydrophilic or hydrophobic matrix.

A composition in the form of a capsule can be prepared using routine encapsulation procedures, for example by incorporation of active compound and excipients into a hard gelatin capsule. Alternatively, a semi-solid matrix of
25 active compound and high molecular weight polyethylene glycol can be prepared and filled into a hard gelatin capsule; or a solution of active compound in polyethylene glycol or a suspension in edible oil, for example liquid paraffin or fractionated coconut oil can be prepared and filled into a soft gelatin capsule.

Tablet binders that can be included are acacia, methylcellulose, sodium
30 carboxymethylcellulose, poly-vinylpyrrolidone (Povidone), hydroxypropyl methylcellulose, sucrose, starch and ethylcellulose. Lubricants that can be used include magnesium stearate or other metallic stearates, stearic acid, silicone fluid, talc, waxes, oils and colloidal silica.

Flavoring agents such as peppermint, oil of wintergreen, cherry flavoring or the like can also be used. Additionally, it may be desirable to add a coloring agent to make the dosage form more attractive in appearance or to help identify the product.

5 The compounds of the invention and their pharmaceutically acceptable salts that are active when given parenterally can be formulated for intramuscular, intrathecal, or intravenous administration.

A typical composition for intra-muscular or intrathecal administration will consist of a suspension or solution of active ingredient in an oil, for example
10 arachis oil or sesame oil. A typical composition for intravenous or intrathecal administration will consist of a sterile isotonic aqueous solution containing, for example active ingredient and dextrose or sodium chloride, or a mixture of dextrose and sodium chloride. Other examples are lactated Ringer's injection, lactated Ringer's plus dextrose injection, Normosol-M and dextrose, Isolyte E,
15 acylated Ringer's injection, and the like. Optionally, a co-solvent, for example, polyethylene glycol; a chelating agent, for example, ethylenediamine tetracetic acid; a solubilizing agent, for example, a cyclodextrin; and an anti-oxidant, for example, sodium metabisulphite, may be included in the formulation. Alternatively, the solution can be freeze dried and then reconstituted with a
20 suitable solvent just prior to administration.

In a preferred embodiment, the glycopeptide derivatives of this invention are formulated in an aqueous solution containing a cyclodextrin. In another preferred embodiment the glycopeptide derivatives of this invention are formulated as a lyophilized powder containing a cyclodextrin or as a sterile
25 powder containing a cyclodextrin. Preferably, the cyclodextrin is hydroxypropyl- β -cyclodextrin or sulfobutyl ether β -cyclodextrin; more preferably, the cyclodextrin is hydroxypropyl- β -cyclodextrin. Typically, in an injectable solution, the cyclodextrin will comprise about 1 to 25 weight percent; preferably, about 2 to 10 weight percent; more preferable, about 4 to 6 weight percent, of the
30 formulation. Additionally, the weight ratio of the cyclodextrin to the glycopeptide derivative will preferably be from about 1:1 to about 10:1.

The compounds of the invention and their pharmaceutically acceptable salts which are active on rectal administration can be formulated as

suppositories. A typical suppository formulation will generally consist of active ingredient with a binding and/or lubricating agent such as a gelatin or cocoa butter or other low melting vegetable or synthetic wax or fat.

5 The compounds of this invention and their pharmaceutically acceptable salts which are active on topical administration can be formulated as transdermal compositions or transdermal delivery devices ("patches"). Such compositions include, for example, a backing, active compound reservoir, a control membrane, liner and contact adhesive. Such transdermal patches may be used to provide continuous or discontinuous infusion of the compounds of the present invention
10 in controlled amounts. The construction and use of transdermal patches for the delivery of pharmaceutical agents is well known in the art. See, e.g., U.S. Patent 5,023,252, issued June 11, 1991. Such patches may be constructed for continuous, pulsatile, or on demand delivery of pharmaceutical agents.

The active compound is effective over a wide dosage range and is
15 generally administered in a pharmaceutically effective amount. It will be understood, however, that the amount of the compound actually administered will be determined by a physician, in the light of the relevant circumstances, including the condition to be treated, the chosen route of administration, the actual compound administered and its relative activity, the age, weight, and
20 response of the individual patient, the severity of the patient's symptoms, and the like.

Suitable doses are in the general range of from 0.01-100 mg/kg/day, preferably 0.1-50 mg/kg/day. For an average 70 kg human, this would amount to 0.7 mg to 7 g per day, or preferably 7 mg to 3.5 g per day. A more preferred
25 dose for a human is about 500 mg to about 2 g per day.

Other suitable formulations for use in the present invention can be found in *Remington's Pharmaceutical Sciences*, Mace Publishing Company, Philadelphia, PA, 17th ed. (1985).

The following formulation examples illustrate representative
30 pharmaceutical compositions of the present invention.

Formulation Example A

This example illustrates the preparation of a representative pharmaceutical composition for oral administration of a compound of this invention:

| | | |
|---|----------------------|---------------------------|
| 5 | Ingredients | Quantity per tablet, (mg) |
| | Active Compound | 200 |
| | Lactose, spray-dried | 148 |
| | Magnesium stearate | 2 |

10 The above ingredients are mixed and introduced into a hard-shell gelatin capsule.

Formulation Example B

This example illustrates the preparation of another representative pharmaceutical composition for oral administration of a compound of this invention:

| | | |
|----|--------------------|---------------------------|
| 15 | Ingredients | Quantity per tablet, (mg) |
| | Active Compound | 400 |
| | Cornstarch | 50 |
| 20 | Lactose | 145 |
| | Magnesium stearate | 5 |

The above ingredients are mixed intimately and pressed into single scored tablets.

Formulation Example C

25 This example illustrates the preparation of a representative pharmaceutical composition for oral administration of a compound of this invention.

An oral suspension is prepared having the following composition.

| Ingredients | |
|-------------|---------------------------------|
| 5 | Active Compound 1.0 g |
| | Fumaric acid 0.5 g |
| | Sodium chloride 2.0 g |
| | Methyl paraben 0.1 g |
| | Granulated sugar 25.5 g |
| 10 | Sorbitol (70% solution) 12.85 g |
| | Veegum K (Vanderbilt Co.) 1.0 g |
| | Flavoring 0.035 ml |
| | Colorings 0.5 mg |
| | Distilled water q.s. to 100 mL |

Formulation Example D

15 This example illustrates the preparation of a representative pharmaceutical composition containing a compound of this invention.

An injectable preparation buffered to a pH of 4 is prepared having the following composition:

| Ingredients | |
|-------------|---|
| 20 | Active Compound 0.2 g |
| | Sodium Acetate Buffer Solution (0.4 M) 2.0 mL |
| | HCl (1N) q.s. to pH 4 |
| | Water (distilled, sterile) q.s. to 20 mL |
| 25 | |

Formulation Example E

This example illustrates the preparation of a representative pharmaceutical composition for injection of a compound of this invention.

A reconstituted solution is prepared by adding 20 mL of sterile water to 1 g of the compound of this invention. Before use, the solution is then diluted with 200 mL of an intravenous fluid that is compatible with the active compound. Such fluids are chosen from 5% dextrose solution, 0.9% sodium chloride, or a mixture of 5% dextrose and 0.9% sodium chloride. Other examples are lactated Ringer's injection, lactated Ringer's plus 5% dextrose injection, Normosol-M and 5% dextrose, Isolyte E, and acylated Ringer's injection

Formulation Example F

This example illustrates the preparation of a representative pharmaceutical composition containing a compound of this invention.

An injectable preparation is prepared having the following composition:

| | |
|----|---|
| 5 | Ingredients |
| | ----- |
| | Active Compound 0.1-5.0 g |
| | Hydroxypropyl- β -cyclodextrin 1-25 g |
| 10 | 5% Aqueous Dextrose Solution (sterile) q.s. to 100 mL |
| | ----- |

The above ingredients are blended and the pH is adjusted to 3.5 ± 0.5 using 0.5 N HCl or 0.5 N NaOH.

Formulation Example G

This example illustrates the preparation of a representative pharmaceutical composition containing a compound of this invention:

A frozen solution suitable for injection is prepared having the following composition:

| | |
|----|---|
| 20 | Frozen Solution |
| | ----- |
| | Active Compound 250 mg to 1000 mg |
| | Hydroxypropyl- β -cyclodextrin 250 mg to 10 g |
| | Excipients - e.g., dextrose 0-50 g |
| | Water for Injection 10-100 mL |
| | ----- |

25 The weight ratio of hydroxypropyl- β -cyclodextrin to the active compound will typically be from about 1:1 to about 10:1.

Representative Procedure: Hydroxypropyl- β -cyclodextrin and excipients, if any, are dissolved in about 80% of the water for injection and the active compound is added and dissolved. The pH is adjusted with 1 M sodium hydroxide to 4.7 ± 0.3 and the volume is then adjusted to 95% of the final volume with water for injection. The pH is checked and adjusted, if necessary, and the volume is adjusted to the final volume with water for injection. The formulation is then sterile filtered through a

0.22 micron filter and placed into a sterile vial under aseptic conditions.
The vial is capped, labeled and stored frozen.

Formulation Example H

This example illustrates the preparation of a representative
5 pharmaceutical composition containing a compound of this invention.

A lyophilized powder useful for preparing an injectable solution is
prepared having the following composition:

| | | |
|----|--|-------------------|
| 10 | <u>Lyophilized Powder</u> | |
| | Active Compound | 250 mg to 1000 mg |
| | Hydroxypropyl- β -cyclodextrin | 250 mg to 10 g |
| | Excipients – e.g., mannitol, sucrose and/or lactose | 0-50 g |
| 15 | Buffer agent – e.g., citrate | 0-500 mg |

The weight ratio of hydroxypropyl- β -cyclodextrin to the active
compound will typically be from about 1:1 to about 10:1.

Representative Procedure: Hydroxypropyl- β -cyclodextrin and excipients
20 and/or buffering agents, if any, are dissolved in about 60% of the water
for injection. The active compound is added and dissolved and the pH is
adjusted with 1 M sodium hydroxide to 4.0-5.0 and the volume is
adjusted to 95% of the final volume with water for injection. The pH is
checked and adjusted, if necessary, and the volume is adjusted to the final
25 volume with water for injection. The formulation is then sterile filtered
through a 0.22 micron filter and placed into a sterile vial under aseptic
conditions. The formulation is then freeze-dried using an appropriate
lyophilization cycle. The vial is capped (optionally under partial vacuum
or dry nitrogen), labeled and stored at room temperature or under
30 refrigeration.

Formulation Example I

This example illustrates the preparation of a representative pharmaceutical composition containing a compound of this invention.

5 A sterile powder useful for preparing an injectable solution is prepared having the following composition:

| | | |
|----|--------------------------------------|-----------------------------|
| | <u>Sterile Powder</u> | |
| | <hr/> | |
| | Active Compound | 250 mg to 1000 mg |
| 10 | Hydroxypropyl- β -cyclodextrin | 250 mg to 10 g ¹ |
| | Excipients | optional |
| | <hr/> | |

The weight ratio of hydroxypropyl- β -cyclodextrin to the active will typically be from about 1:1 to about 10:1.

15 Representative Procedure: Hydroxypropyl- β -cyclodextrin and the active compound (and any excipients) are dispersed into an appropriate sterile container and the container is sealed (optionally under partial vacuum or dry nitrogen), labeled and stored at room temperature or under refrigeration.

Administration of representative formulations H and I to a Patient

20 The pharmaceutical formulations described in formulation examples H and I above can be administered intravenously to a patient by the appropriate medical personnel to treat or prevent gram-positive infections. For administration, the above formulations can be reconstituted and/or diluted with a diluent, such as 5% dextrose or sterile saline, as follows:

25 Representative Procedure: The lyophilized powder of formulation example H (e.g., containing 1000 mg of active compound) is reconstituted with 20 mL of sterile water and the resulting solution is further diluted with 80 mL of sterile saline in a 100 mL infusion bag. The diluted solution is then administered
30 to the patient intravenously over 30 to 120 minutes.

Formulation Example I

This example illustrates the preparation of a representative pharmaceutical composition for topical application of a compound of this invention.

| | | |
|----|---------------------------------|-------------|
| 5 | Ingredients | grams |
| | Active compound | 0.2-10 |
| | Span 60 | 2 |
| | Tween 60 | 2 |
| 10 | Mineral oil | 5 |
| | Petrolatum | 10 |
| | Methyl paraben | 0.15 |
| | Propyl paraben | 0.05 |
| | BHA (butylated hydroxy anisole) | 0.01 |
| 15 | Water | q.s. to 100 |

All of the above ingredients, except water, are combined and heated to 60°C with stirring. A sufficient quantity of water at 60°C is then added with vigorous stirring to emulsify the ingredients, and water then added q.s. 100 g.

20

Formulation Example K

This example illustrates the preparation of a representative pharmaceutical composition containing a compound of this invention.

A suppository totaling 2.5 grams is prepared having the following composition:

| | | |
|----|---|---------|
| 25 | Ingredients | |
| | Active Compound | 500 mg |
| | Witepsol H-15* | balance |
| 30 | (* triglycerides of saturated vegetable fatty acid; a product of Riches-Nelson, Inc., New York, N.Y.) | |

Utility

The glycopeptide compounds of this invention, and their pharmaceutically acceptable salts, are useful in medical treatments and exhibit biological activity, including antibacterial activity, which can be demonstrated in using the tests described herein. Such tests are well known to those skilled in the art, and are referenced and described in Lorian "Antibiotics in Laboratory Medicine", Fourth Edition, Williams and Wilkins (1991).

Accordingly, this invention provides methods for treating bacterial or infectious diseases, especially those caused by Gram-positive microorganisms, in animals. The compounds of this invention are particularly useful in treating infections caused by methicillin-resistant staphylococci. Also, the compounds are useful in treating infection due to enterococci, including vancomycin-resistant enterococci (VRE). Examples of such diseases include severe staphylococcal infections, such as staphylococcal endocarditis and staphylococcal septicemia. The animal treated may be either susceptible to, or infected with, the microorganism. The method of treatment typically comprises administering to the animal an amount of a compound of this invention which is effective for this purpose.

In practicing this method, the antibiotic can be administered in a single daily dose or in multiple doses per day. The treatment regimen may require administration over extended periods of time, for example, for several days or for from one to six weeks. The amount per administered dose or the total amount administered will depend on such factors as the nature and severity of the infection, the age and general health of the patient, the tolerance of the patient to the antibiotic and the microorganism or microorganisms in the infection.

The following synthetic and biological examples are offered to illustrate this invention and are not to be construed in any way as limiting the scope of this invention.

EXAMPLES

In the examples below, the following abbreviations have the following meanings. Any abbreviations not defined have their generally accepted meaning. Unless otherwise stated, all temperatures are in degrees Celsius.

| | | | |
|----|----------|---|--|
| 5 | ACN | = | acetonitrile |
| | BOC, Boc | = | <i>tert</i> -butoxycarbonyl |
| | DIBAL-H | = | diisobutylaluminum hydride |
| | DIPEA | = | diisopropylethylamine |
| | DMF | = | <i>N,N</i> -dimethylformamide |
| 10 | DMSO | = | dimethyl sulfoxide |
| | eq. | = | equivalent |
| | EtOAc | = | ethyl acetate |
| | Fmoc | = | 9-fluorenylmethoxycarbonyl |
| | HOBT | = | 1-hydroxybenzotriazole hydrate |
| 15 | Me | = | methyl |
| | PyBOP | = | benzotriazol-1-yloxytris(pyrrolidino)phosphonium hexafluorophosphate |
| | TEMPO | = | 2,2,6,6-tetramethyl-piperidinyloxy, free radical |
| | TFA | = | trifluoroacetic acid |
| 20 | THF | = | tetrahydrofuran |
| | TLC, tlc | = | thin layer chromatography |

In the following examples, vancomycin hydrochloride semi-hydrate was purchased from Alpharma, Inc. Fort Lee, NJ 07024 (Alpharma AS, Oslo
 25 Norway). Other reagents and reactants are available from Aldrich Chemical Co., Milwaukee, WI 53201.

General Procedure A Reductive Alkylation of Vancomycin

To a mixture of vancomycin (1 eq.) and the desired aldehyde (1.3 eq.) in
 30 DMF was added DIPEA (2 eq.). The reaction was stirred at ambient temperature for 1-2 hours and monitored by reverse-phase HPLC. Methanol and NaCNBH₃ (1 eq.) were added to the solution, followed by TFA (3 eq.). Stirring was continued for an additional hour at ambient temperature. After the reaction was complete, the methanol was removed *in vacuo*. The residue was precipitated in
 35 acetonitrile. Filtration gave the crude product which was then purified by reverse-phase HPLC. If desired, other glycopeptides antibiotics may be used in this procedure.

General Procedure B

Synthesis of S-Decyl Mercaptoacetaldehyde

Under nitrogen, to a suspension of potassium carbonate (27 g, 200 mmol) in acetone (100 mL) was added decyl bromide (10 mL, 50 mmol) and
5 mercaptoethanol (4.4 mL, 63 mmol). The suspension was stirred at room temperature for 2 days, then partitioned between water and 80% hexane/ethyl acetate. The organic phase was washed with 2N sodium hydroxide, dried over magnesium sulfate, and the volatiles removed under vacuum to give S-decyl
10 mercaptoethanol (10.2 g, 47 mmol) as a colorless liquid that was used without further purification.

Under nitrogen, S-decyl mercaptoethanol (50 g, 230 mmol), *N,N*-diisopropylethylamine (128 mL, 730 mmol) and methylene chloride (400 mL) were cooled to -40 °C. To this solution was added, over 15 minutes, a solution
15 of sulfur trioxide pyridine complex (116 g, 730 mmol) in dimethyl sulfoxide (600 mL) and methylene chloride (200 mL). After addition, the mixture was stirred a further 15 minutes at -40 °C, then 600 mL ice water was added. The mixture was removed from the cooling bath, 1 L water was added, and the liquids partitioned. The organic phase was washed with 1 L of 1 N hydrochloric
20 acid, and dried over magnesium sulfate. Filtration gave 600 mL liquid, which was diluted with 600 mL hexane and passed through 200 mL silica. The silica was washed with 100 mL 50% methylene chloride/hexane, then 300 mL methylene chloride. The combined organics were concentrated in vacuo to give
S-decyl mercaptoacetaldehyde (48 g, 220 mmol) as a colorless liquid that was used without further purification.

25

Example 1

Preparation of Compound 5

(Formula II wherein R¹⁷ is -CH(COOH)CH₂COOH,

R¹⁸ is hydrogen, R¹⁹ is hydrogen, and R²⁰ is -CH₂CH₂-S-(CH₂)₉CH₃)

Under nitrogen, to a solution of S-decyl mercaptoacetaldehyde (crude, 48
30 g, 220 mmol) in *N,N*-dimethylformamide (1.4 L) was added solid vancomycin hydrochloride hydrate (173 g, 110 mmol) followed by *N,N*-diisopropylethylamine (58 mL, 330 mmol). The suspension was stirred

vigorously at room temperature for 2 hours, in the course of which time all the vancomycin fully dissolved. Then trifluoroacetic acid (53 mL, 690 mmol) was added. The solution was stirred a further 90 minutes. Then solid sodium cyanoborohydride (10.5 g, 170 mmol) followed by methanol (800 mL) were
5 added. After three hours, the mixture was poured into water (7 L), resulting in a slightly cloudy solution. The pH of the solution was adjusted to 5 with saturated sodium bicarbonate, resulting in the formation of a white precipitate. This precipitate was collected by filtration, washed with water, then ethyl acetate, and dried under vacuum to give a compound of formula II wherein R¹⁷ is OH; R¹⁸ is
10 hydrogen, R¹⁹ is hydrogen, and R²⁰ is -CH₂CH₂-S-(CH₂)₉CH₃) (compound a).

A solution of benzotriazole-1-yl-oxy-tris-pyrrolidino-phosphonium hexafluorophosphate (PyBOP, 16.5 g, 32 mmol) in *N,N*-dimethylformamide (DMF, 82.5 mL) was prepared. Under nitrogen, compound a from above, (crude, 57 g) was dissolved in DMF (250 mL) at room temperature. 1-
15 Hydroxybenzotriazole (4.7 g, 35 mmol) was added, then L-aspartic acid bis-fluorenylmethyl ester trifluoroacetate (17 g, 28 mmol), followed by *N,N*-diisopropylethylamine (18 mL, 105 mmol). To this solution was added 54 mL of the PyBOP solution, and the mixture stirred for 35 minutes. Then a further 16.5 mL of the PyBOP solution was added. After another 30 minutes, 8.6 mL
20 more PyBOP solution was added. 35 minutes later, the final 1.1 mL of the PyBOP solution was added. The progress of the reaction over this time was monitored by reverse-phase HPLC. 55 minutes after the final PyBOP addition, piperidine (37 mL, 375 mmol) was added and the solution stirred for 25 minutes at room temperature. The mixture was then concentrated under vacuum to
25 around 100 mL volume, then added to 2.5 L acetonitrile. The resulting precipitate was stirred overnight, filtered, washed with acetonitrile, and dried under vacuum to give the title compound, which was purified by reverse-phase HPLC.

Example 2**Preparation of Compound 7**

(Formula II wherein R¹⁷ is -CH(COOH)CH₂COOH,

R¹⁸ is hydrogen, R¹⁹ is hydrogen, and R²⁰ is -CH₂CH₂O(CH₂)₉CH₃,

- 5 N^{VAN}-decyloxyethyl Vancomycin bistrifluoroacetate (3 g, 1.6 mmol) and NH₂-Asp (OFm)-(OFm) trifluoroacetate (1.5 g, 2.4 mmol) was dissolved in anhydrous DMF (30 mL). To this solution was added DIPEA (1.5 mL, 8.9 mmol). After 5 minutes stirring, a solution of PyBOP (0.94 g, 1.8 mmol) and HOBT (0.28 g, 1.8 mmol) in anhydrous DMF (1 mL) was added and the reaction
- 10 was stirred for 1.5 hours. The solution was then poured into diethyl ether (150 mL) and the resulting solid was filtered, washed with diethyl ether (3 x 30 mL) and dried under reduced pressure. Once dry, the white solid was re-dissolved in DMF (25 mL) and piperidine (5.5 mL) and stirred for 45 minutes. The solution was then poured into diethyl ether (150 mL) and the resulting solid was filtered,
- 15 washed with MeCN (2 x 50 mL), diethyl ether (2 x 50 mL), and dried under reduced pressure. The crude product was purified by reverse-phase HPLC to give the title compound. MS calculated (M⁺) 1748.7; found (MH⁺) 1749.7.

Example 3**Preparation of Compound 15**

- 20 (Formula II wherein NR¹⁷R¹⁸ is formula III wherein R⁶ is N-(D-glucamine), R¹⁹ is hydrogen, and R²⁰ is -CH₂CH₂O(CH₂)₉CH₃,

- To a mixture of N^{VAN}-decyloxyethyl Vancomycin bistrifluoroacetate (2 g, 1.1 mmol) in DMF (20 mL) was added a solution of PyBOP (0.61 g, 1.2 mmol) and HOBT (0.16 g, 1.2 mmol) in DMF (2 mL) followed by NMM (0.12 mL, 1.1
- 25 mmol). After 30 minutes, additional NMM was added (0.13 mL, 1.2 mmol). After 10 minutes a solution of NH₂-Glu (NH-Me-D-Glucamine)-OH hydrochloride and NMM (0.35 mL, 3.3 mmol) in DMF (4 mL) was added and the reaction was stirred for 2 hours. The thick reaction was then diluted with DMF (10 mL) and NH₂-Asp(OFm)-O(Fm) trifluoroacetate (3.2 g, 5.5 mmol),
- 30 DIPEA (1.1 mL, 6.6 mmol), and a solution of PyBOP (0.61 g, 1.2 mmol) and HOBT (0.16 g, 1.2 mmol) in DMF (2 mL) were added sequentially. After 1 hour of stirring at room temperature additional PyBOP (0.31 g, 0.6 mmol) and

HOBT (0.09 g, 0.6 mmol) in DMF (2 mL) was added. The reaction was stirred for 20 minutes and then added to diethyl ether (250 mL). The resulting precipitate was filtered, washed with MeCN (50 mL), diethyl ether (50 mL), and dried under reduced pressure to give 3.1 g white solid.

- 5 The crude solid was taken up in DMF (15 mL) and piperidine (4 mL) and stirred for 30 minutes. The reaction was then added to diethyl ether and the resulting solid was filtered, dried under reduced pressure, and then purified by reverse phase HPLC to give the titled compound. MS calculated (M⁺) 2055.0; found (MH⁺) 2055.9

- 10 Using the above procedures and the appropriate starting materials the compounds shown in Table I were prepared. The mass spectral data for these compounds were as follows:

| Compound No. | MW (freebase) | Observed MH* |
|--------------|---------------|--------------|
| 1 | 1704.6 | 1705.9 |
| 2 | 1718.7 | 1719.4 |
| 3 | 1732.7 | 1733.2 |
| 4 | 1746.7 | 1747.9 |
| 5 | 1764.8 | 1765.6 |
| 6 | 1761.7 | |
| 7 | 1748.7 | 1749.7 |
| 8 | 1765.0 | 1765.6 |
| 9 | 1825.1 | 1825.7 |
| 10 | 1809.1 | 1809.7 |
| 11 | 1807.11 | 1807.8 |
| 12 | 1762.7 | 1764.1 |
| 13 | 2055.0 | |
| 14 | 2054.0 | 2054.7 |
| 15 | 2055 | 2055.9 |

Example 4

Determination of Antibacterial Activity

A. In Vitro Determination of Antibacterial Activity

1. Determination of Minimal Inhibitory Concentrations (MICs)

5 Bacterial strains were obtained from either American Type Tissue Culture Collection (ATCC), Stanford University Hospital (SU), Kaiser Permanente Regional Laboratory in Berkeley (KPB), Massachusetts General Hospital (MGH), the Centers for Disease Control (CDC), the San Francisco Veterans' Administration Hospital (SFVA) or the University of California San
10 Francisco Hospital (UCSF). Vancomycin resistant enterococci were phenotyped as Van A or Van B based on their sensitivity to teicoplanin. Some vancomycin resistant enterococci that had been genotyped as Van A, Van B, Van C1 or Van C2 were obtained from the Mayo Clinic.

Minimal inhibitory concentrations (MICs) were measured in a
15 microdilution broth procedure under NCCLS guidelines. Routinely, the compounds were serially diluted into Mueller-Hinton broth in 96-well microtiter plates. Overnight cultures of bacterial strains were diluted based on absorbance at 600 nm so that the final concentration in each well was 5×10^5 cfu/mL. Plates were returned to a 35°C incubator. The following day (or 24 hours in the case of
20 Enterococci strains), MICs were determined by visual inspection of the plates. Strains routinely tested in the initial screen included methicillin-sensitive *Staphylococcus aureus* (MSSA), methicillin-resistant *Staphylococcus aureus*, methicillin-sensitive *Staphylococcus epidermidis* (MSSE), methicillin-resistant *Staphylococcus epidermidis* (MRSE), vancomycin sensitive *Enterococcus*
25 *faecium* (VSE Fm), vancomycin sensitive *Enterococcus faecalis* (VSE Fs), vancomycin resistant *Enterococcus faecium* also resistant to teicoplanin (VRE Fm Van A), vancomycin resistant *Enterococcus faecium* sensitive to teicoplanin (VRE Fm Van B), vancomycin resistant *Enterococcus faecalis* also resistant to teicoplanin (VRE Fs Van A), vancomycin resistant *Enterococcus*
30 *faecalis* sensitive to teicoplanin (VRE Fs Van B), enterococcus gallinarum of the Van A genotype (VRE Gm Van A), enterococcus gallinarum of the Van C-1 genotype (VRE Gm Van C-1), enterococcus casseliflavus of the Van C-2 genotype (VRE Cs Van C-2), enterococcus flavescens of the Van C-2 genotype

(VRE Fv Van C-2), and penicillin-sensitive *Streptococcus pneumoniae* (PSSP) and penicillin-resistant *Streptococcus pneumoniae* (PSRP). Because of the inability of PSSP and PSRP to grow well in Mueller-Hinton broth, MICs with those strains were determined using either TSA broth supplemented with defibrinated blood or blood agar plates. Compounds which had significant activity against the strains mentioned above were then tested for MIC values in a larger panel of clinical isolates including the species listed above as well as non-speciated coagulase negative *Staphylococcus* both sensitive and resistant to methicillin (MS-CNS and MR-CNS). In addition, they were tested for MICs against gram negative organisms, such as *Escherichia coli* and *Pseudomonas aeruginosa*.

2. Determination of Kill Time

Experiments to determine the time required to kill the bacteria were conducted as described in Lorian, "Antibiotics in Laboratory Medicine", Fourth Edition, Williams and Wilkins (1991). These experiments were conducted normally with both staphylococcus and enterococcus strains.

Briefly, several colonies were selected from an agar plate and grown at 35°C under constant agitation until it achieved a turbidity of approximately 1.5 and 10⁸ CFU/mL. The sample was then diluted to about 6 x 10⁶ CFU/mL and incubated at 35°C under constant agitation was continued. At various times aliquots were removed and five ten-fold serial dilutions were performed. The pour plate method was used to determine the number of colony forming units (CFUs).

In general, the compounds of the invention were active in the above tests *in vitro* tests and demonstrated a broad spectrum of activity.

B. In Vivo Determination of Antibacterial Activity

1. Acute Tolerability Studies in Mice

In these studies, a compound of this invention was administered either intravenously or subcutaneously and observed for 5-15 minutes. If there were no adverse effects, the dose was increased in a second group of mice. This dose incrementation continued until mortality occurred, or the dose was maximized.

Generally, dosing began at 20 mg/kg and increased by 20 mg/kg each time until the maximum tolerated dose (MTD) is achieved.

2. Bioavailability Studies in Mice

Mice were administered a compound of this invention either intravenously or subcutaneously at a therapeutic dose (in general, approximately 50 mg/kg). Groups of animals were placed in metabolic cages so that urine and feces could be collected for analysis. Groups of animals (n = 3) were sacrificed at various times (10 min, 1 hour and 4 hours). Blood was collected by cardiac puncture and the following organs were harvested—lung, liver, heart, brain, kidney, and spleen. Tissues were weighed and prepared for HPLC analysis. HPLC analysis on the tissue homogenates and fluids was used to determine the concentration of the test compound or its present. Metabolic products resulting from changes to the test compound were also determined at this juncture.

3. Mouse Septicemia Model

In this model, an appropriately virulent strain of bacteria (most commonly *S. aureus*, or *E. Faecalis* or *E. Faecium*) was administered to mice (N=5 to 10 mice per group) intraperitoneally. The bacteria was combined with hog gastric mucin to enhance virulence. The dose of bacteria (normally 10^5 - 10^7) was that sufficient to induce mortality in all of the mice over a three day period. One hour after the bacteria was administered, a compound of this invention was administered in a single dose either IV or subcutaneously. Each dose was administered to groups of 5 to 10 mice, at doses that typically ranged from a maximum of about 20 mg/kg to a minimum of less than 1 mg/kg. A positive control (normally vancomycin with vancomycin sensitive strains) was administered in each experiment. The dose at which approximately 50% of the animals are saved was calculated from the results.

4. Neutropenic Thigh Model

In this model, antibacterial activity of a compound of this invention was evaluated against an appropriately virulent strain of bacteria (most commonly *S. aureus*, or *E. Faecalis* or *E. Faecium*, sensitive or resistant to vancomycin). Mice were initially rendered neutropenic by administration of cyclophosphamide at

200 mg/kg on day 0 and day 2. On day 4 they were infected in the left anterior thigh by an IM injection of a single dose of bacteria. The mice were then administered the test compound one hour after the bacteria and at various later times (normally 1, 2.5, 4 and 24 hours) the mice were sacrificed (3 per time point) and the thigh excised, homogenized and the number of CFUs (colony forming units) were determined by plating. Blood was also plated to determine the CFUs in the blood.

5. Pharmacokinetic Studies

The rate at which a compound of this invention is removed from the blood can be determined in either rats or mice. In rats, the test animals were cannulated in the jugular vein. The test compound was administered via tail vein injection, and at various time points (normally 5, 15, 30, 60 minutes and 2, 4, 6 and 24 hours) blood was withdrawn from the cannula. In mice, the test compound was also administered via tail vein injection, and at various time points. Blood was normally obtained by cardiac puncture. The concentration of the remaining test compound was determined by HPLC.

In general, the compounds of the invention were active in the above test in vivo and demonstrated a broad spectrum of activity.

Example 5

Determination of Tissue Accumulation

A. Tissue Distribution Using Radiolabeled Compound

This procedure is used to examine the tissue distribution, excretion and metabolism of a radiolabeled test compound in both male and female rats following intravenous infusion at 10 mg/kg. Male and female Sprague-Dawley rats (n = 2 per sex per compound) are dosed with ³H-labelled test compound at 10 (400 µCi/kg) and 12.5 mg/kg (100 µCi/kg), respectively, via intravenous infusion (~2 min). The test compound is formulated in 5% hydroxypropyl-β-cyclodextrin as 2.5 mg/mL solution. Urine and feces are cage collected over 24 hours period. At 24 hours after dosing, animals are sacrificed and tissues are removed. Serum, urine and tissues are analyzed for total radioactivity by oxidation followed by liquid scintillation counting. Urine and selected tissues samples are extracted and analyzed by reverse phase HPLC with radioactive flow detector for the presence of potential metabolites.

B. Tissue Accumulation Following Single Dose

This procedure is used to evaluate tissue distribution of a test compound in rats following single dose administration by infusion. Male Sprague-Dawley rats (n = 3 per dose groups) are dosed with 50 mg/kg of a test compound. Two formulations are used: 30% PEG 400 and 10% sulfobutylether- β -cyclodextrin. Urine samples are cage collected over 24 hours. Blood samples are collected for serum chemistry and concentration determination. Liver and kidneys are removed for histology evaluation. One kidney and part of the liver are homogenized for concentration analysis using reverse phase HPLC with UV detection. Drug concentrations in urine and serum samples are determined by LC-MS analysis.

C. Tissue Distribution Following Multiple Doses

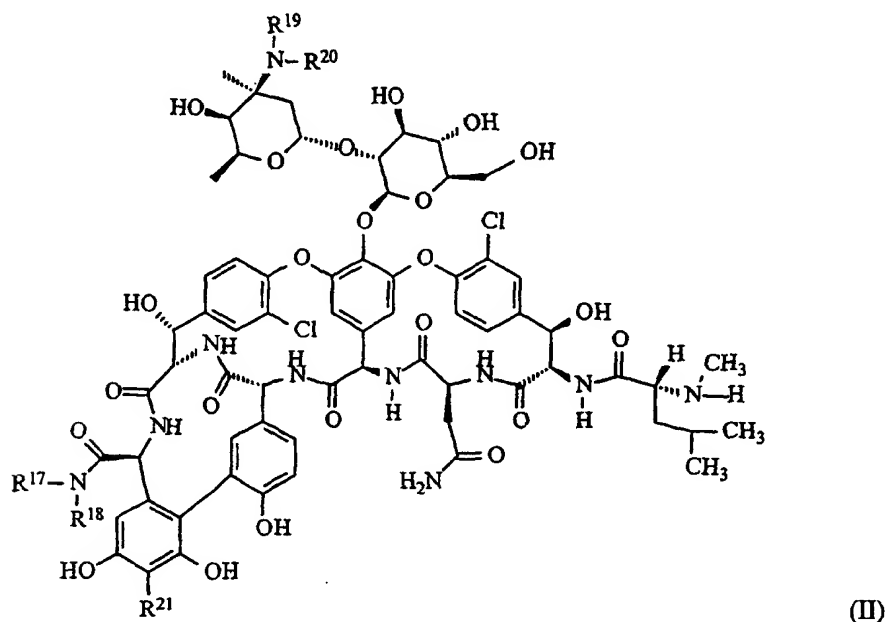
This procedure is used too evaluate the potential tissue accumulation of a test compound in rats following multiple dose administration by intravenous infusion. Male and female Sprague-Dawley rats (n = 4 per sex per dose group) are dosed with a test compound at 12.5, 25 and 50 mg/kg per day for seven days. Animals are sacrificed at day 1 (n = 3 per sex per dose group) following the last dose administered. One animal per sex per dose group is retained as recovery animal and sacrificed at day 7 following the last dose administered. The test compound is formulated in 5% hydroxypropyl- β -cyclodextrin or 1% sucrose/4.5% dextrose. Urine samples are cage collected at days 1 and 7 post-dose. Blood samples are collected for serum chemistry and concentration determination. Liver and kidneys are removed for histology evaluation. One kidney and part of the liver are homogenized for concentration analysis using reverse phase HPLC with UV detection. Drug concentrations in urine and serum samples are determined by LC-MS analysis.

While the present invention has been described with reference to the specific embodiments thereof, it should be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation, material, composition of matter, process, process step or steps, to the objective, spirit and scope of the present invention. All such modifications are intended to be within the scope of the claims appended

hereto. Additionally, all publications, patents, and patent documents cited hereinabove are incorporated by reference herein in full, as though individually incorporated by reference.

WHAT IS CLAIMED IS:

1. A glycopeptide substituted at the C-terminus with a substituent that comprises two or more carboxy groups; or a pharmaceutically acceptable salt, or stereoisomer, or prodrug thereof; provided the glycopeptide is not 1) teicoplanin A2 substituted at the C-terminus with a nitrogen-linked glutamic acid, 2) teicoplanin aglycon (TD) substituted at the C-terminus with a nitrogen-linked glutamic acid; or 3) a compound of formula II:

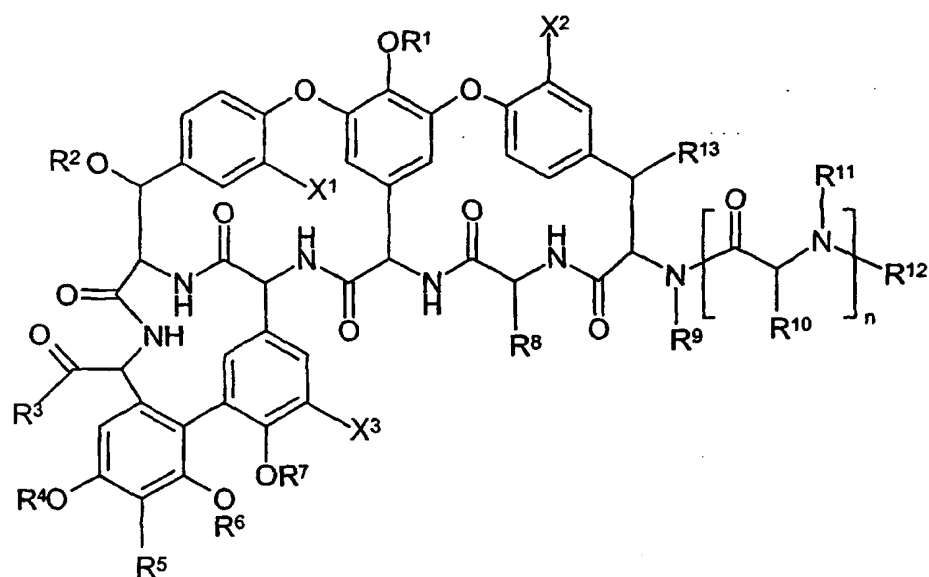


- a) wherein NR^{17} is nitrogen-linked aspartic acid; R^{18} is hydrogen; R^{19} is hydrogen; R^{20} is 2-(decylamino)ethyl; and R^{21} is hydrogen;
- b) wherein NR^{17} is nitrogen-linked aspartic acid; R^{18} is hydrogen; R^{19} is hydrogen; R^{20} is 2-(9-hydroxydecylamino)ethyl; and R^{21} is hydrogen;
- c) wherein R^{17} is 1,4-dicarboxybutyl; R^{18} is hydrogen; R^{19} is hydrogen; R^{20} is 2-(decylamino)ethyl; and R^{21} is hydrogen;
- d) wherein NR^{17} is nitrogen-linked aspartic acid; R^{18} is hydrogen; R^{19} is hydrogen; R^{20} is 2-(decylamino)ethyl; and R^{21} is $-\text{CH}_2-\text{N}-(\text{D-glucamine})$;

- e) wherein R¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-[4-(4-chlorobenzoyloxy)benzylamino]ethyl; and R²¹ is hydrogen;
- 5 f) wherein NR¹⁷ is 5-(2-carboxypyrrolidin-1-ylcarbonyl)-5-(2-carboxy-3-phenylpropylamino)pentylamino; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is hydrogen;
- 10 g) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is -CH₂-N-(N-CH₃-D-glucamine);
- h) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(decylamino)ethyl; and R²¹ is N-[2-(2-hydroxyethoxy)ethyl]-aminomethyl; or
- 15 i) wherein NR¹⁷ is nitrogen-linked aspartic acid; R¹⁸ is hydrogen; R¹⁹ is hydrogen; R²⁰ is 2-(4-isobutylbenzyl)ethyl; and R²¹ is N-[2-(2-hydroxyethoxy)ethyl]aminomethyl.

2. The glycopeptide of claim 1 wherein the substituent comprises two carboxy groups.
- 20 3. The glycopeptide of claim 2 wherein the substituent is a nitrogen-linked aspartic acid or a nitrogen linked glutamic acid.

4. The glycopeptide of claim 1 which is a compound of formula I:



(I)

wherein:

- R^1 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl, heterocyclic and $-R^a-Y-R^b-(Z)_x$; or R^1 is a saccharide group optionally substituted with $-R^a-Y-R^b-(Z)_x$, R^f , $-C(O)R^f$, or $-C(O)-R^a-Y-R^b-(Z)_x$;

R^2 is hydrogen or a saccharide group optionally substituted with $-R^a-Y-R^b-(Z)_x$, R^f , $-C(O)R^f$, or $-C(O)-R^a-Y-R^b-(Z)_x$;

- 10 R^3 is a nitrogen-linked, oxygen-linked, or sulfur-linked substituent comprising two or more carboxy groups;

R^4 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, $-R^a-Y-R^b-(Z)_x$, $-C(O)R^d$ and a saccharide group optionally substituted with $-R^a-Y-R^b-(Z)_x$, R^f , $-C(O)R^f$, or $-C(O)-R^a-Y-R^b-(Z)_x$;

- 15 R^5 is selected from the group consisting of hydrogen, halo, $-CH(R^c)-NR^cR^c$, $-CH(R^c)-NR^cR^c$, $-CH(R^c)-R^z$, $-CH(R^c)-NR^c-R^a-C(=O)-R^z$, and $-CH(R^c)-NR^c-R^a-Y-R^b-(Z)_x$;

R^6 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, $-R^a-Y-R^b-(Z)_x$, $-C(O)R^d$ and a saccharide group optionally substituted with $-NR^c-R^a-Y-R^b-(Z)_x$, or R^5 and R^6 can be joined, together with the atoms to which they are attached, form a

- 5 heterocyclic ring optionally substituted with $-NR^c-R^a-Y-R^b-(Z)_x$;

R^7 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, $-R^a-Y-R^b-(Z)_x$, and $-C(O)R^d$;

- 10 R^8 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic;

R^9 is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic;

- 15 R^{10} is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic; or R^8 and R^{10} are joined to form $-Ar^1-O-Ar^2-$, where Ar^1 and Ar^2 are independently arylene or heteroarylene;

- 20 R^{11} is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic, or R^{10} and R^{11} are joined, together with the carbon and nitrogen atoms to which they are attached, to form a heterocyclic ring;

- 25 R^{12} is selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl, heterocyclic, $-C(O)R^d$, $-C(NH)R^d$, $-C(O)NR^cR^e$, $-C(O)OR^d$, $-C(NH)NR^cR^e$ and $-R^a-Y-R^b-(Z)_x$, or R^{11} and R^{12} are joined, together with the nitrogen atom to which
- 30 they are attached, to form a heterocyclic ring;

R^{13} is selected from the group consisting of hydrogen or $-OR^{14}$;

R^{14} is selected from hydrogen, $-C(O)R^d$ and a saccharide group;

each R^a is independently selected from the group consisting of alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted alkynylene;

each R^b is independently selected from the group consisting of a covalent
5 bond, alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted alkynylene, provided R^b is not a covalent bond when Z is hydrogen;

each R^c is independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl,
10 heteroaryl, heterocyclic and -C(O)R^d;

each R^d is independently selected from the group consisting of alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl and heterocyclic;

15 R^e is a saccharide group;

each R^f is independently alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, substituted cycloalkyl, cycloalkenyl, substituted cycloalkenyl, aryl, heteroaryl, or heterocyclic;

R^x is an N-linked amino saccharide or an N-linked heterocyclic;

20 X¹, X² and X³ are each independently selected from hydrogen or chloro;

each Y is independently selected from the group consisting of oxygen, sulfur, -S-S-, -NR^c-, -S(O)-, -SO₂-, -NR^cC(O)-, -OSO₂-, -OC(O)-, -NR^cSO₂-, -C(O)NR^c-, -C(O)O-, -SO₂NR^c-, -SO₂O-, -P(O)(OR^c)O-, -P(O)(OR^c)NR^c-, -OP(O)(OR^c)O-, -OP(O)(OR^c)NR^c-, -OC(O)O-,
25 -NR^cC(O)O-, -NR^cC(O)NR^c-, -OC(O)NR^c-, -C(=O)-, and -NR^cSO₂NR^c-;

each Z is independently selected from hydrogen, aryl, cycloalkyl, cycloalkenyl, heteroaryl and heterocyclic;

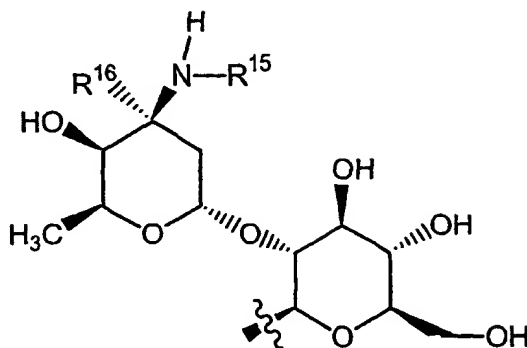
n is 0, 1 or 2; and

x is 1 or 2;

30 or a pharmaceutically acceptable salt, or stereoisomer, or prodrug thereof.

5. The glycopeptide of claim 4 wherein R¹ is a saccharide group optionally substituted with -R^a-Y-R^b-(Z)_x, R^f, -C(O)R^f, or -C(O)-R^a-Y-R^b-(Z).

6. The glycopeptide of claim 4 wherein R^1 is a saccharide group of the formula:



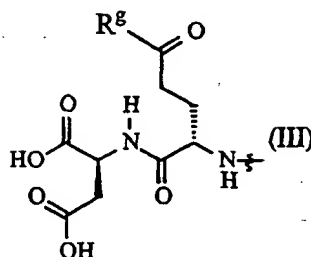
wherein R^{15} is $-R^a-Y-R^b-(Z)_x$, R^f , $-C(O)R^f$, or $-C(O)-R^a-Y-R^b-(Z)_x$; and R^{16} is hydrogen or methyl.

7. The glycopeptide of claim 6 wherein R^{15} is $-\text{CH}_2\text{CH}_2-\text{NH}-(\text{CH}_2)_9\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NH}-(\text{CH}_2)_8\text{CH}_3$; $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-\text{NH}-(\text{CH}_2)_7\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2-\text{NHSO}_2-(\text{CH}_2)_9\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{NHSO}_2-(\text{CH}_2)_{11}\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_{10}\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{CH}_3$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_9\text{CH}_3$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_3-\text{CH}=\text{CH}-(\text{CH}_2)_4\text{CH}_3$ (*trans*); $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-$
 $\text{S}-(\text{CH}_2)_7\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}(\text{O})-(\text{CH}_2)_9\text{CH}_3$; $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_6\text{Ph}$;
 $-\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-(\text{CH}_2)_8\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{NH}-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2-\text{NH}-\text{CH}_2-4-[4-(\text{CH}_3)_2\text{CHCH}_2-]-\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{NH}-\text{CH}_2-4-(4-\text{CF}_3-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{S}(\text{O})-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}(\text{O})-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2-4-[3,4-\text{di-Cl-PhCH}_2\text{O-}]-\text{Ph}$; $-\text{CH}_2\text{CH}_2-\text{NHSO}_2-\text{CH}_2-4-$
 $[4-(4-\text{Ph})-\text{Ph}]-\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-\text{CH}_2-4-(4-\text{Cl}-\text{Ph})-\text{Ph}$;
 $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-\text{CH}_2-4-(\text{Ph}-\text{C}\equiv\text{C-})-\text{Ph}$; $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-4-(4-\text{Cl}-\text{Ph})-$
 Ph ; or $-\text{CH}_2\text{CH}_2\text{CH}_2-\text{NHSO}_2-4-(\text{naphth-2-yl})-\text{Ph}$.

8. The glycopeptide of claim 6 wherein R^3 comprises two carboxy groups.

9. The glycopeptide of claim 8 wherein R^3 is a nitrogen-linked aspartic acid or a nitrogen linked glutamic acid.

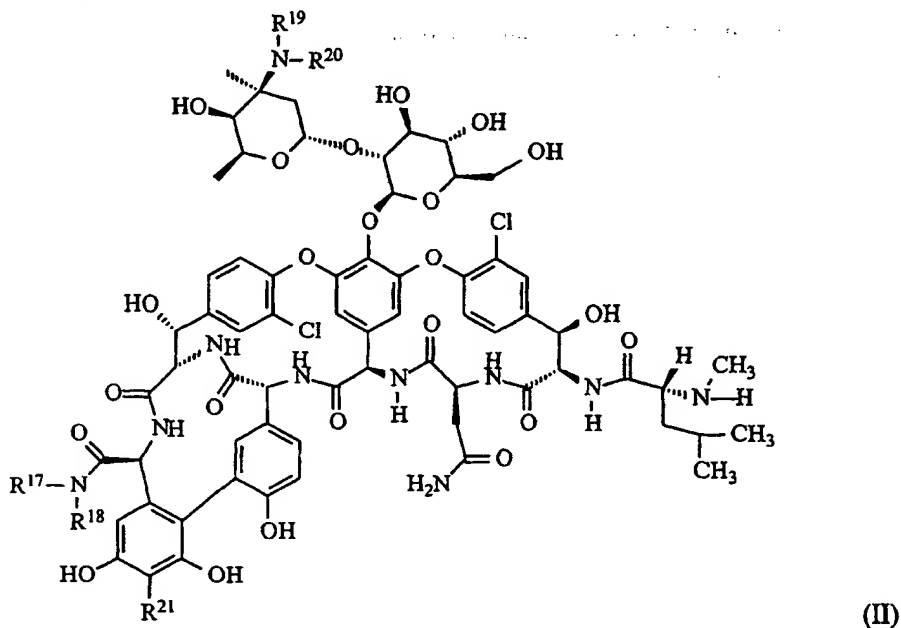
10. The glycopeptide of claim 6 wherein R^3 is a nitrogen-linked radical of formula III:



wherein R^g is a saccharide group.

11. The glycopeptide of claim 10 wherein R^g is N-(D-glucamine) or N-(D-glucosamine).

12. The glycopeptide of claim 4 which is a compound of formula II:



wherein:

- 10 R^{17} is a dicarboxy-substituted alkyl group having from 3 to 10 carbon atoms;
 R^{18} is selected from the group consisting of hydrogen and alkyl;
 R^{19} is hydrogen;
 R^{20} is $-R^a-Y-R^b-(Z)_x$;
 R^{21} is hydrogen

R^a is selected from the group consisting of alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted alkynylene;

- R^b is selected from the group consisting of a covalent bond, alkylene, substituted alkylene, alkenylene, substituted alkenylene, alkynylene and substituted
- 5 alkynylene, provided R^b is not a covalent bond when Z is hydrogen;

Y is selected from the group consisting of sulfur, -S(O)- and -SO₂-;

each Z is independently selected from hydrogen, aryl, cycloalkyl, cycloalkenyl, heteroaryl and heterocyclic; and

- x is 1 or 2;
- 10 or a pharmaceutically acceptable salt, or stereoisomer, or prodrug thereof.

13. A pharmaceutical composition comprising a pharmaceutically acceptable carrier and a therapeutically effective amount of a compound of any of claims 1-12.

- 15 14. The pharmaceutical composition of Claim 13, which comprises a cyclodextrin.

15. A compound as described in any one of claims 1-12 for use in medical therapy.

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16. The use of a compound as described in any one of claims 1-12 for preparing a medicament useful for treating a bacterial disease in a mammal.

17. A method of treating a mammal having a bacterial disease, the method
- 25 comprising administering to the mammal a therapeutically effective amount of a glycopeptide of any one of claims 1, 4, or 12.

18. A method of treating a mammal having a bacterial disease, the method comprising administering to the mammal a therapeutically effective amount of
- 30 a pharmaceutical composition of claim 13.

